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"TO THE WEST, WHEN WIND, TIDE AND WEATHER SERVE, THERE IS SUFFICIENT WATER TO LET OUT THE FLEET . . . OVER THIS LOWER CHANNEL, ASWING FROM WIRE CABLES FROM TWO TOWERS, HANGS THE TRAP'S IRON GATE. THE TOWERS RISE FROM A POPULACE FRIENDLY TO EVERY NATION IN THE WORLD BUT ITS OWN . . . AND FOND OF EXPLOSIVES."—*Sea Power.*

THE DEVELOPMENT OF OUR FLEET AND NAVAL STATIONS

BY W. L. CATHCART, PHILADELPHIA, PA.

Member of the Society

MY subject, "The Development of Our Fleet and Naval Stations," is so broad that only a rapid review of its salient points will be possible to me.

I need scarcely say that this whole question of naval strength is one of impelling interest to engineers. The European conflict has shown in many striking ways that war by land and sea is now very largely but a matter of applied science, of physics and chemistry, and chiefly of engineering in all its branches.

Years ago, Theodore Roosevelt said, in an expression which has become classic, that the naval officer of our time is fundamentally a "Fighting Engineer." This description is wholly accurate with regard to the structures and mechanisms of naval war—its huge hulls and giant turbines, its colossal guns, its dynamos, wireless, torpedoes, and air craft. The naval officer has added functions as a strategist and tactician, but it is clear that the engineer is a mighty factor in the sea power of our time.

WHY WE NEED A GREAT NAVY

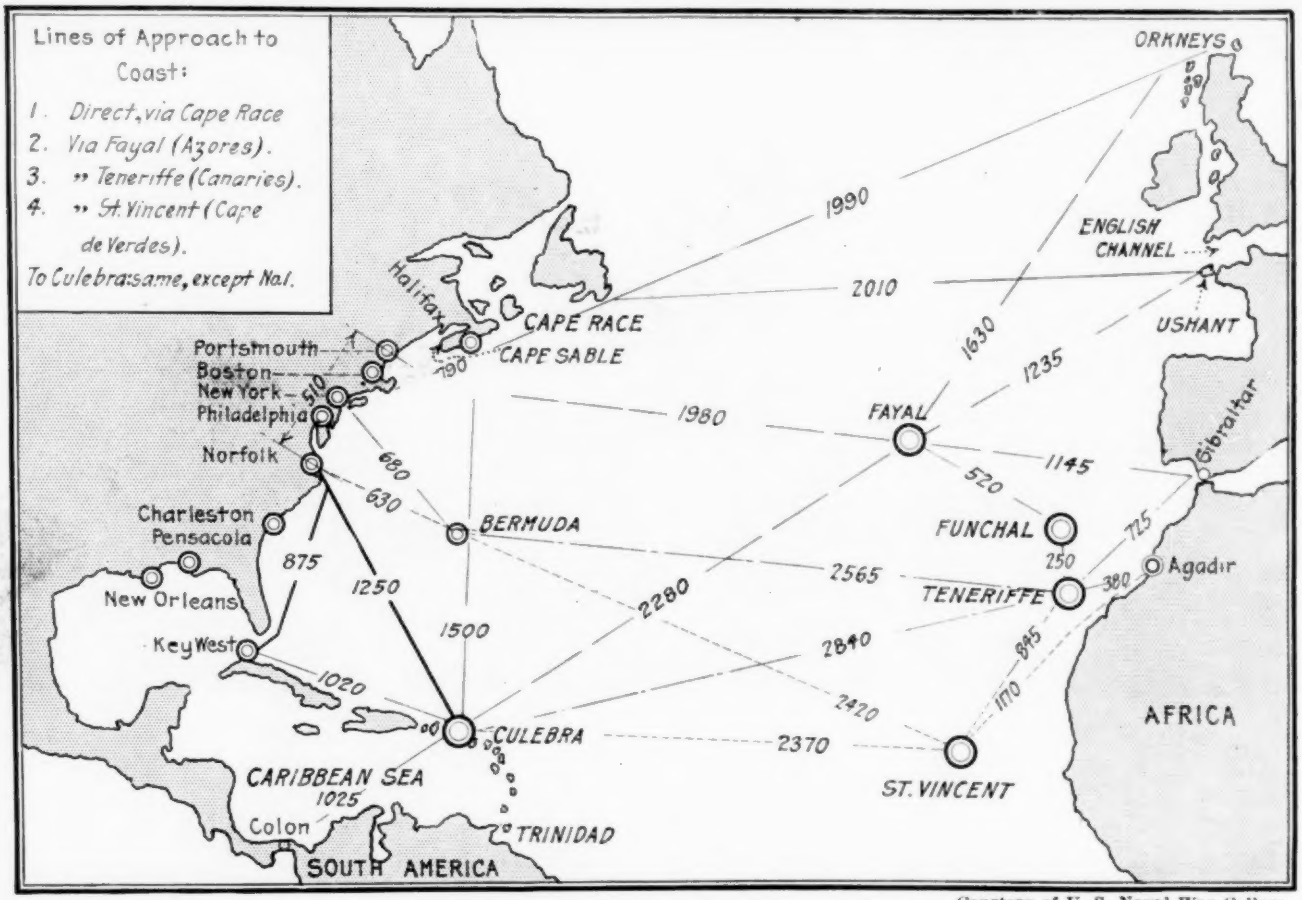
Why does the United States need a great navy? In the first place, our country is the richest, and, owing to its vast extent of coast line, the most vulnerable of all the great Powers. And, second, like a modern Atlas, it staggers—diplomatically and militarily—under the weight of some national policies which, while just, are as world-irritating and war-breeding as any that history has known. These policies are: The Monroe Doctrine, The Neutralization of the Panama Canal, The Maintenance of the Rights of Neutrals, The Exclusion of Asiatic Races, and The "Open Door" in China.

The Monroe Doctrine extends our "political suzerainty over two continents, comprising a fourth of the habitable earth and one-half of its unexploited wealth." Excluding Canada and the United States, this vital and yet war-inviting policy covers twenty republics, having a total area of nine million square miles, a population of eighty millions, and a foreign trade of nearly three billion dollars. And all this is to be guarded from European seizure by the force behind a doctrine which is not international law, but simply a bluff declaration by the United States that Europe shall not enter in!

This doctrine has been a sleeping danger to this Republic for nearly a century now. Its slumber has been due chiefly to the lack of means for the swift transfer of fleets and armies across the Atlantic, and the extreme delicacy of the balance of power in Europe. The progress of steam navigation has swept the first of these away, and, as for the second, who dare predict political conditions in Europe when this war closes?

Now, take the Panama Canal. By international law, it is a part of the territory of the United States, and it is also, as a military and commercial highway, one of the world's greatest prizes. So, we must defend it. Further, by the provisions of the Hay-Pauncefote Treaty of 1901, we agreed that "the canal shall be free and open to the vessels of commerce and of war of all nations"—that is, we guaranteed its neutralization. Either of these obligations necessitates a powerful, fully sup-

Address (abridged) delivered at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, December 8, 1916.



Courtesy of U. S. Naval War College.

PARTIAL STRATEGIC CHART, NORTH ATLANTIC OCEAN

ported fleet, and neutralization presents as well most complex and dangerous problems for the future.

We have glanced at the possible effects of but two of our national policies, and they alone hold menace enough for the future. Trans-oceanic attack can be met primarily only by a fleet. Do you wonder, then, that naval strategists foresee a time when—not in aggression, but in national defense—the mighty thunder of American guns will roll out in mid-Atlantic or on the sun-lit Caribbean, along the coasts of Europe or at the threshold of the Far East?

The surest way to delay the coming of that time is to have behind the parleys of our diplomacy a naval force stronger than those of our possible foes. All history shows that diplomacy, when backed by guns enough, can keep the peace, but notes without powder behind them are futile.

STRATEGIC SITUATION, EASTERN COAST

The elements of naval strength are: First, the fleet—its ships and men; and, second, its shore stations—navy yards at home and naval bases in our island possessions—which dock, repair, and supply the ships, and from which the fleet may strike. Manifestly, the location of these stations with regard to our possible battlegrounds of the future is of primary importance. Let us glance briefly at the strategic situation of our eastern and western coasts in this respect, as shown by charts whose use is permitted through the courtesy of Rear Admiral Knight, President of the Naval War College, and Captain J. S. McKean, Assistant to the Chief of Operations.

When invasion by a European Power is threatened, our Navy Department will know only that the enemy has set sail from some port across the Atlantic. His specific course and objective—on our coast or in the Caribbean—will be unknown. Our fleet, if strong enough, would take the offensive-defensive, and attack the enemy a thousand miles or more at sea. To locate him, our admiral would send out a long line of scouts to scour the seas in a great arc from Cape Sable in Nova Scotia to Trinidad at the lower entrance of the Caribbean Sea.

There would be four principal points of departure for this enemy fleet: from the Orkneys, the northern base of the British Grand Fleet; from the mouth of the English Channel; from the Straits of Gibraltar; or from some point on the African coast, as Agadir.

On these four lines of approach to our coast the distances range between 2800 and 4200 sea miles. To Culebra—which, if we do not acquire St. Thomas, will be our challenging Caribbean outpost—these lines are from 3200 to 3900 miles long. In the present state of naval science, these relatively great distances make successful invasion impossible, if the enemy fleet must conduct *continuous operations* on our coast *from its home bases*, or even from these eastern Atlantic islands.

There are two main reasons for this. In the first place, a naval force, steaming far from its bases, must be followed by a train of supply vessels, which train becomes huge when that force is large. And, second, fleets cannot invade. So the enemy fleet must be followed by troop transports.

And, further, unless the enemy had previously gained command of the sea, these helpless fleets of transports and supply ships of his must be guarded always while en route throughout the whole period of his operations, and by a stronger force than we could bring against them.

From these considerations, several things are clear: First—disregarding the Caribbean for the time—any enemy but Great Britain must, for successful invasion, first *seize a naval base on our coast,* from which to conduct succeeding operations. To seize that base, he must first *defeat decisively* our fleet—either destroying it, blockading it, or forcing it to withdraw to a distance. Then, and then only, when the enemy has *won command of the sea, will his convoys* of troops and supplies *be safe.*

Naval bases suitable for hostile operations are fairly numerous on our coast. For example, Delaware Bay, Narragansett Bay, Provincetown, Mass., and several others, in their present defenseless state, could be seized with ease if our fleet were first defeated.

As to our naval stations on this coast, they all lie within an air-line distance of 500 miles, although our Atlantic and Gulf coast lines are more than 3000 miles long.

If an enemy should gain possession of these 500 miles of coast, our dreadnaughts would be homeless, unless the fleet could flee to the Bay of Panama, since the yards at Charleston, Pensacola, and New Orleans are equipped for small craft only. As to these conditions, Rear Admiral Edwards says:

"There is not a dry dock owned by the Government or by anyone else on the South Atlantic and Gulf coasts which will take any of our super-dreadnaughts. There is not a single stationary or floating crane on these coasts which will remove from or install in a battleship either a modern turret gun, a Scotch marine boiler, or an assembled low-pressure turbine of the kind now fitted in our large naval colliers, tankers, and battleships."

These conditions give our strategists just cause for concern in their bearing on our undefended line of communications, 875 miles long, from Cape Hatteras to Key West, and on the distance, one-half greater, from Culebra to Norfolk.

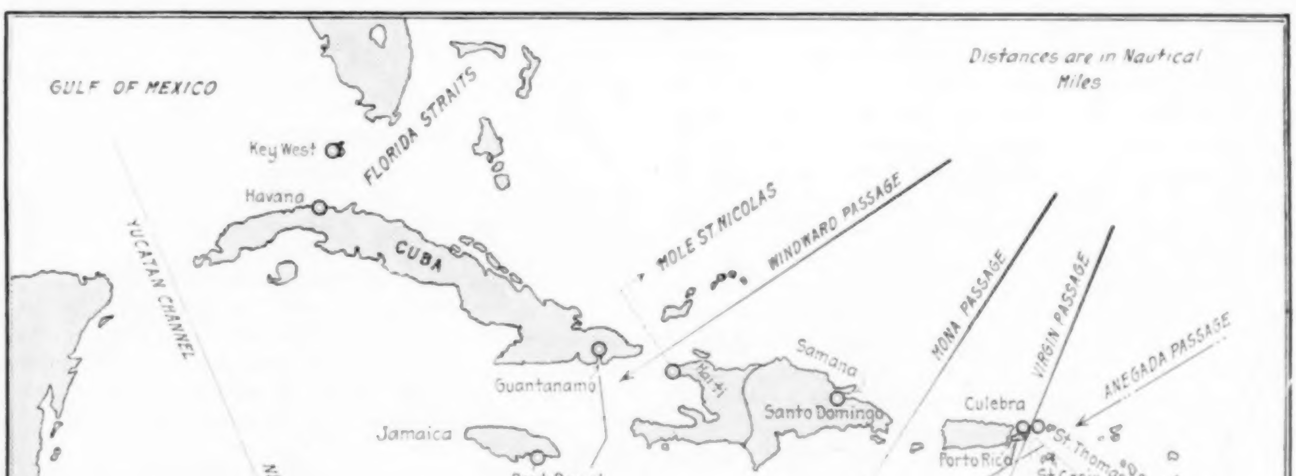
STRATEGIC SITUATION, CARIBBEAN SEA

The Caribbean Sea is—as Admiral Mahan once wrote of it—"preëminently the domain of sea power." For its size, it has more strategic positions than any other important expanse of sea on the globe. For the United States, its mastery in war is almost vital, since that mastery is the bulwark of our defense of the Monroe Doctrine and the Panama Canal.

No invasion of the United States is possible until our fleet has first been put out of the reckoning. If, then, the enemy must thus eliminate our fleet, it seems probable that he would endeavor to force action where our naval strength is most vulnerable—that is, off Culebra, where our ships would be more than 1200 miles from their home bases.

Again, *for continuous operations,* the enemy must have a naval base of his own on or near our territory, and the seizure of a small island would be far easier than that of a base on our coast.

Finally, if thus established at some point like St. Thomas or Culebra, with our fleet negligible for the time, the enemy could raid our South Atlantic and Gulf coasts at will; could flank all our routes to the Caribbean, and when—with full command of the sea—his convoys of troops had come he could invade the Canal Zone, 1040 miles from St. Thomas. Possession of the Canal would give him not only a powerful lever in bringing pressure on our Government, but would enable



STRATEGIC CHART, CARIBBEAN SEA

him to block the retreat of our defeated fleet to Gatun Lake or the Bay of Panama, and to prevent the coming of reinforcements from the Pacific.

Glance now at the geography of the sea. On its northern border lie Porto Rico, which we own; Haiti and Santo Domingo, which are under our virtual protectorate, and Cuba, whose independence we have guaranteed. Doubtless, every port in these islands would be open to our use in time of war.

There are five entrances to the sea along this northern border —the Yucatan Channel via the Florida Straits from the Atlantic, and the Windward, Mona, Virgin, and Anegada Passages. Dominating the Florida Straits stands Havana like a new-world Gibraltar. Near the southeastern end of Cuba lies our base, Guantanamo, which, with Mole St. Nicolas in Haiti, commands the Windward Passage. Similarly, Samana Bay in Santo Domingo controls the Mona Passage, Culebra and St. Thomas the Virgin Passage, and the latter and St. Croix the Anegada Passage, which is the main route from Europe to the Canal.

Jamaica, with its naval base, Port Royal, seemingly dominates all by its central location. But, while Jamaica has thus a commanding strategic position, it is lacking in strength against attack and in its resources for supplies and refitting. Hence, for military support and supplies, it would be dependent in war on its lines of communication with other British colonial and home ports, and from those ports it is both distant and isolated. Further, our base at Guantanamo flanks its communications with all of these ports.

Now as to our two naval bases, Guantanamo and Culebra: Guantanamo is but 700 miles from the Canal, and, as it flanks all routes to Colon except that from Jamaica, its location centrally is almost as good. Further, it has surpassing advantages in the fact that it is on a large island, which has not only great native resources, but also direct railway communication with manufacturing centers in the United States except for the short sea link between Key West and Havana. Hence, supplies can reach Guantanamo by interior land lines immune from attack by sea if the Florida Straits be guarded effectively.

As compared with Guantanamo, Culebra is about 600 miles farther to the eastward, and hence it has a far better command of the eastern entrances to the sea, flanking all routes through them by short runs of 350 to 500 miles. Again, it is but a few miles from Porto Rico, which is in itself difficult of defense. Further, as a little island, it could be fortified and garrisoned at proportionately low expense. And finally, as a salient, it flanks the lines of approach to our coast.

All of these advantages, and more, hold for St. Thomas, just across the Virgin Passage from Culebra. It also is a small island, it is still farther eastward, has a better command of the Anegada Passage, and its harbor can be strongly defended by fortifications in the high hills surrounding it. The best argument for its acquisition by the United States is, however, the negative: Suppose the unthinkable—that we should let St. Thomas pass into the hands of a strong military power unfriendly to us. Then our base at Culebra would be confronted by a rival fortress on the further shore of that narrow Virgin Passage. These conditions would be as if Gibraltar faced an equally formidable and alien "Rock," with but the Straits between.

And *the menace of that fortress would stretch far beyond the Caribbean* to our trade routes to South America, and even to our coast. For within a radius of 1000 to 1400 miles from it lie New Orleans, Key West, Charleston, Norfolk, and New York—a distance through which raiding battle cruisers or even a dreadnaught fleet could steam and fight, with ample fuel remaining for their return, if necessary, to St. Thomas.

We find, then, that the destiny of nations has given the United States full opportunity for holding the strategic mastery of the Caribbean Sea through its present and prospective tenure of predominating positions there. But strategic dominance on the sea means nothing if the sites on which it depends are not fully equipped, fortified, and garrisoned and an adequate fleet based there, since a more powerful enemy would simply wrest them from us. So these neglected West Indian bases of ours give cause for grave concern. *With them, some day, the fate of this Republic may rest.*

STRATEGIC SITUATION, NORTH PACIFIC

Let us close our strategic review with a brief consideration of our western coast and our outlying possessions in the North Pacific Ocean, where remarkable conditions exist.

In the first place, the United States owns on the shores from Panama to Kiska in the Aleutian Islands every important strategic position except three—the Galapagos Islands, Magdelena Bay in Mexico, and Esquimault, the fortified port of British Columbia. Thus, strategically—if these be developed —our power over these shores is predominating for two-thirds the width of that great ocean.

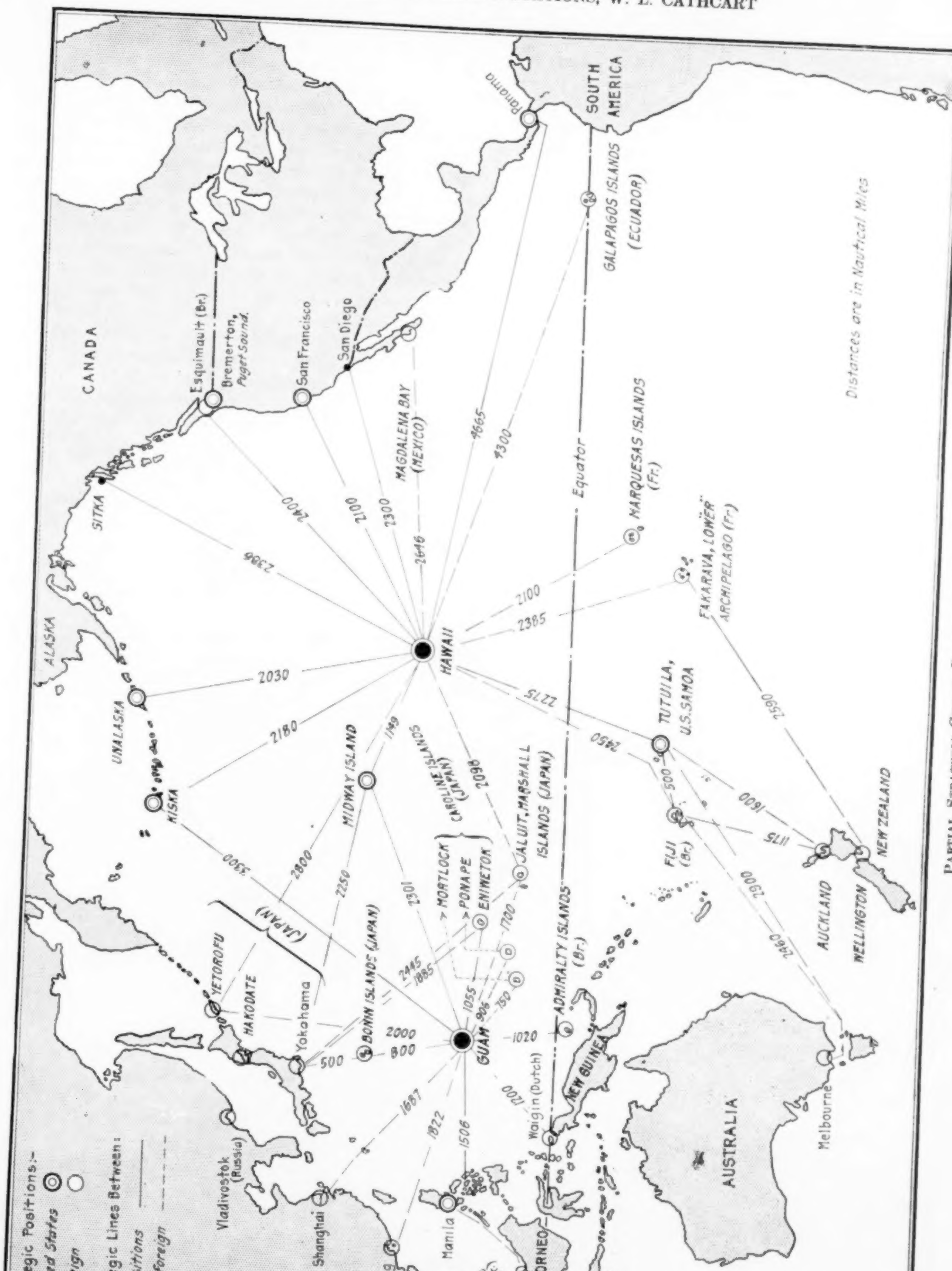
Further, spanning the Pacific like the piers of a colossal bridge from Panama lie our islands of the Hawaiian Group, and our other island, Guam, in the Ladrones, which is *the key to the military control of this northern ocean.* Then 1150 miles west of Hawaii is Midway, useless to us except as a future coaling station. And finally, 2300 miles southward, is Tutuila in American Samoa, one of the noblest harbors in the South Seas.

Steaming at 12 knots an hour from Panama, it would take a fleet 12 days to reach San Francisco, 16 days to Honolulu, 28 to Guam, and 33 to Manila. So no fleet stationed on our western coast in war could protect the Philippines and our interests in the "Open Door" in China. Hence, *for their defense and that of Alaska*—which is virtually an overseas possession 2000 miles from San Francisco—*we must rely on our island bases, Guam and Hawaii.*

Hawaii is the center of communications—*the strategic focus*—of the eastern half of the North Pacific Ocean. This means that a fleet based there can strike with equal ease, in offense or defense, at all points on the great arc of coast line from Kiska to Panama. *Hawaii thus dominates the whole strategic front formed by the shores of the eastern half of the North Pacific Ocean.*

Similarly, the strategic lines of the western Pacific all intersect near our possession, *Guam, which is thus the strategic focus of that half of the ocean—and hence a menace in war to every important position there,* from Japan's northernmost one at Yetorofu and that of Russia at Vladivostok, down the Chinese coast to Singapore in the Straits Settlements. Well within the circle of Guam's protective area lie the Philippines, indefensible of themselves, whose single stronghold is the little island, Corregidor, in Manila Bay. And also, well within its reach, stands that—now closing—"Open Door" in China. Guam is small—about seven by twenty-nine miles—has a harbor which, by dredging and building a breakwater, would shelter a fair-sized fleet, and is readily capable of defense by fortifications and mines.

Finally, a noteworthy fact as to our chain of bases bridging the North Pacific, is that the strategic line from Panama through Hawaii to Guam cuts the similar British line from



Partial Strategic Chart, Pacific Ocean

Courtesy of U. S. Naval War College.

Esquimault to Australia and New Zealand. In view of this and of the focal relations of Guam and Hawaii to that northern ocean, *the strategical predominance of the United States in those waters is*—in a geographical sense, at least—*unquestionable.*

Guam and Hawaii, if made ocean fortresses, would be our Malta and Gibraltar against aggression by any enemy sailing from the Far East—from Vladivostok, Yokohama, or Singapore. If in war we had strong fleets based there, no enemy from Asiatic waters would dare to pass Guam without masking or reducing it, and destroying or dispersing its fleet. And, later, he would have a similar victory to win off Hawaii before the Pacific coast would meet the shock of war. And yet, like Guantanamo and Culebra, Guam lies neglected and undeveloped there, at the very threshold of the Far East—an easy prey for any foreign nation which would dare war with us to take it. And, too, the fortification and equipment of Hawaii proceed but slowly.

As to the very striking relation of these ocean outposts to Pacific coast defense, Captain McKean, formerly of the Naval War College and now Assistant to the Chief of Operations, says:

"With Guam converted into a Pacific Gibraltar, Honolulu . . . becomes a secondary base, and can be less strongly held against attack from the West. . . . In effect, their (Guam and Honolulu) fortifications would be an expanded and intelligently elaborated coast defense, which, combined with an adequate fleet to bind them together, would keep the enemy from ever approaching our coast."

THE NEEDS OF OUR NAVAL STATIONS

In the upbuilding and maintenance of the Navy, we shall need all the navy yards we have—and more. As a whole, these yards lack much, not only in the dredging of their channels of approach, but in modern equipment for building and repair, both as to hulls and machinery. The need of dry docks and of channels to these yards, which would be deep enough for our largest vessels at all stages of the tide, is an amazing instance of naval unpreparedness. We have been building, and are to build, giant dreadnaughts, which, at present, can be docked at only four widely separated navy yards —New York, Norfolk, Puget Sound and Hawaii. The possible consequences, after but one great naval battle, are appalling. I have pointed out the imperative need of repair facilities on our southern Atlantic coast for war vessels of the largest size. At present, Charleston seems to be the only suitable location there. Admiral Benson, Chief of Operations —in recommending a navy yard of the first-class on this southern coast—says, if "there should be any naval engagements south of Hatteras, it would be of vital importance to be able to use all the facilities that the Charleston yard offers"—and that yard is now but a very minor affair.

As to the naval bases for the defense of our outlying possessions and as frontier outposts for our coasts, the admirable locations which we now have are as yet but "the substance of things hoped for," and fatally lacking in much.

Admiral Knight, President of the Naval War College, says: "It is my opinion that the completed bases at Guam and Culebra, including the defenses * * * would cost in the neighborhood of $15,000,000—in other words, about the price of a battleship." Shall we hazard the safety of our fleet and imperil our national defense to save an amount equal to the cost of but one dreadnaught?

Every important naval station on our coast and island possessions should have its Flying Base and be equipped also with its "Mother Ship," carrying from ten to twenty aeroplanes, all fitted with wireless. These flying scouts could report the location and formation of an enemy fleet some days in advance of its appearance off the coast.

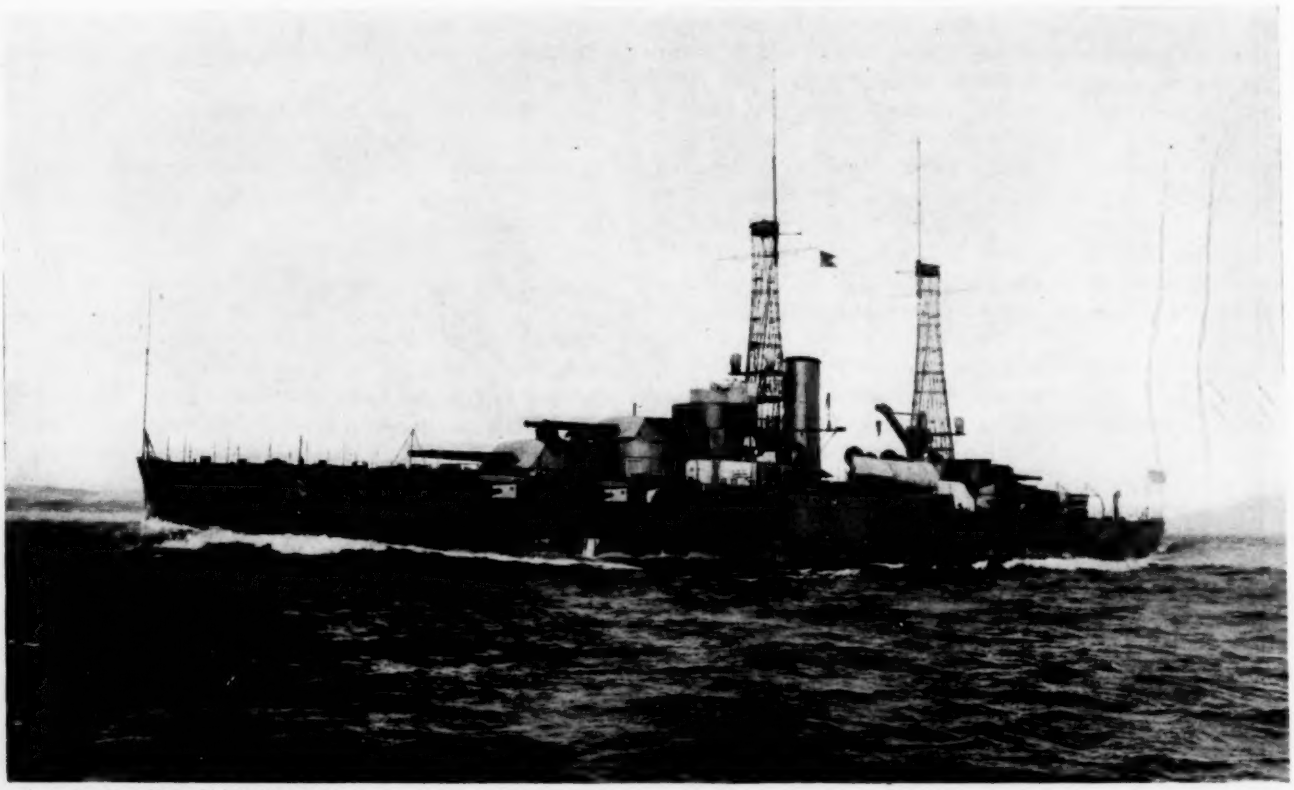


Photo by New York Shipbuilding Co.

U. S. S. Oklahoma, the Latest Addition to the Battleship Fleet

HOW LARGE SHOULD OUR NAVY BE?

Not for aggression, but to keep the peace, and to exert fitly what Mahan called "the silent force of sea power," the United States needs a great Navy. How big should that Navy be?

Several conditions affect the answer. First, our unequaled and ill-defended wealth, inviting spoliation. Second, our immense territory, which—from Eastport, Maine, to Manila—stretches more than half around the world. Third, the factor of distance with regard to that territory—which factor has no parallel in Europe. England, for example, is today waging the greatest naval war of all history at but 400 miles from her own shores, while, with us, the distances to the Caribbean Sea, to the Panama Canal, to Alaska and the Philippines, are from three to twenty times greater. Fourth, the fact that "the United States Navy is really a 'Disunited States' navy," since, like Russia, with her Baltic and Black Sea littorals, we have two widely separated coasts, linked, in our case, by a canal which may fail us in a crisis—either by slides or by treacherous or direct attack with high explosives on its locks.

It would take 60 days for our fleet to steam from the Caribbean Sea around South America to Panama. The Austro-Prussian War of 1866 was won at Sadowa in nineteen days after its beginning. The Franco-Prussian War of 1870 ended at Sedan in fifty-one days after its declaration. The British Fleet—the very keystone of Allied success in the existing war—was started instantly on its fateful run of but 400 miles by the telegraphic order, "Go!" By sixty days' delay in sudden war we might lose the lands of an empire—Alaska, Hawaii, Guam, and Samoa—in the Pacific Ocean.

Hence, from every viewpoint—of strategy and of common sense—the conclusion is inevitable that we should keep permanently in each ocean a battle fleet strong enough to defeat decisively any probable enemy there.

This in itself means a great Navy, but the General Board states that we should go farther still, that "the Navy of the United States should ultimately be equal to the most powerful maintained by any other nation of the world."

MODERN BATTLE RANGES

The great growth in the possible battle range during recent years has been forced by the increase in torpedo range, which, officially, is now 10,000 yards (5.7 miles), but probably is considerably more.

Since guns can now hit with straddling salvos as far as the fire control officer in the top can see the decks of the enemy ship, the question of the limiting battle range is now in theory one of visibility only—of extending, instrumentally, the range of human vision beyond the horizon which the curvature of the earth makes.

Courtesy of *Sea Power*.

U. S. S. Pennsylvania, the Greatest Fighting Ship in the World

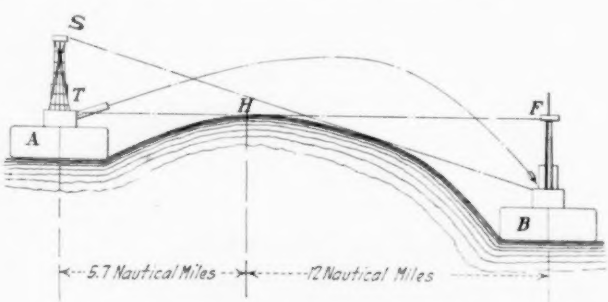
In discussing this subject, Commander Ralph Earle of our Navy gives the distance of the sea horizon from the turret sights as 11,400 yards (5.7 sea miles) in perfectly clear weather. But the "spotter's" platform at the top of the mast of an enemy ship would be about 110 feet above his sea level, and hence would be visible—just above our turret-sight horizon—for a distance of 12 sea miles more, making the total distance of visible objects 17.7 sea miles, or 20.4 land miles (35,400 yards).

However, other conditions than visibility affect this fighting limit. These are, first, the small percentage of hits at extreme ranges; and, second, the wearing out of the guns by erosion of the bore.

The British, during the battle off the Falkland Islands, scored but two per cent of hits out of a total of 750 shots. As to erosion, it is due primarily to the high temperature of the exploding charge and the friction of its gases, although chemical action probably plays a part. With nitroglycerine powder, this temperature reaches 3178 deg. cent. The propelling powder used by our Army and Navy is a low explosive of the nitrocellulose type, which has less tendency to burn out the bore of the gun. Owing to erosion, the accuracy-life of our 12-in., 45-caliber naval guns is but 120 rounds. I am enabled to show the effect of erosion, during a test to destruction, through the courtesy of Major Edward P. O'Hern, U. S. Army, who says:

"The illustration indicates the condition of the interior of a 0.30-caliber machine-gun barrel, after a rapid-fire test of 3000 rounds in which nitroglycerine powder was used. The firings were made with unusual rapidity, and without the presence of the usual water jacket surrounding the barrel."

In view of these facts many gunnery experts believe that, under present conditions, no battle, broadside to broadside, is probable at a greater range than 8 miles (14,000 yards), if closer action can be forced, since no admiral would be justified in wasting his ammunition and wearing out his guns by firing at a greater distance. In chasing, however, guns will doubtless be fired at any range at which a hit is possible.



LIMITING BATTLE RANGE OF A WAR VESSEL

A U. S. ship
B Enemy ship
H Horizon
S Spotter's platform, U. S. ship
T Turret sight, U. S. ship
F Spotter's platform, enemy ship

THE MARKSMANSHIP OF OUR NAVY

A battleship is essentially but a mobile gun platform, and its ability to hit with that primary weapon, the gun, is virtually its sole reason for existence. Occasionally there appear in the press adverse, and usually uninformed, criticisms of the Navy's target practice, of the failures of our "Hitless Navy." The facts, however, as furnished by Admiral Fletcher, tell a different story. In the salvo firing of one of our dreadnaughts in West Indian waters last winter, five shots were fired simultaneously at the same moving target, 30 ft. high by 90 ft. long. The results were photographed. The distance between the extreme splashes in the line of fire was taken as 400 yd.—the maximum dispersion of our projectiles in the line of fire. In one position between the extreme splashes, three shots would have struck a battleship, and in almost any position between she would have been hit by two or more shots.

This salvo was fired at a range of 9000 yards (5.1 land miles), with reduced charges so as to give the same angle of fall as that with a full charge at a range of 16,350 yards (9.3 miles). The hits for these two ranges would thus be the same, since all conditions as to aiming would be identical except the apparent size of the target, which does not matter with the telescopic sight. The firing ship was steaming at high speed, 15 knots. The target was towed at 6 or 7 knots on a non-parallel course, so that the range was changing constantly.

Admiral Fletcher also refers to some later practice, in which one of our ships made seven hits on this small target out of 42 shots. The ship was the battleship *Michigan*. Her commanding officer, Captain Brittain, stated that he opened fire at 18,000 yards (10.2 miles), and continued at an average range of 16,000 yards (9.1 miles). As before, the firing ship was moving at 15 knots and the target was towed on a non-parallel course.

This shooting has not been surpassed—if, indeed, it has been equaled—by any navy, and we are warranted in the belief that the *Michigan* and her consorts are making our dreadnaught fleet the equal of any in the world in marksmanship. The nation hears little of their work in this, since the reports of target practice are confidential. The two examples I have given were revealed only by statements drawn from officers by the House Committee on Naval Affairs.

Courtesy Maj. Edward P. O'Hern, U. S. A.

CROSS-SECTION OF A MACHINE-GUN BARREL AFTER FIRING 3000 ROUNDS WITH NITROGLYCERINE POWDER

FIRE CONTROL

The accuracy of the target practice which has just been described is due primarily to fire control, which is vital to precision in modern gunnery, and hence to victory in a sea fight. For example, compare the *Michigan's* abnormally high percentage of hits with the similar results at the battle of Santiago. There, under the old hit-or-miss methods, our fleet fired 9000 shots at relatively short range, and made but 120 hits, or 1.3 per cent.

The reasons for this amazing inaccuracy—common to all navies then—were, as Captain Sims says, because "each gun pointer estimated the distance of the enemy for himself, made his own estimate for deflection (*i.e.*, the speed of the enemy across the line of fire), decided at what point on the ship's roll to fire, and how fast his line of sight was moving across the target and consequently how far his line of sight should be off the target (approaching it), when he pulled the lock string. It was because no man could acquire this skill to a high degree, and, particularly, because no group of pointers could acquire it to the same degree, that we could not hit anything except at very short ranges."

The foundation of modern methods of fire control was laid by Commander (now Rear-Admiral) Bradley A. Fiske of our Navy, in his invention and successful application of the telescopic sight to naval guns in 1892. The credit for originating the present system of accurate aiming belongs to Vice-

Admiral Sir Percy Scott of the British Navy. The introduction of this system into our own Navy is due wholly to Captain William S. Sims, who, in 1902—supported vigorously by Theodore Roosevelt, then President—overcame the opposition of the Navy Department, and virtually forced the New Gunnery on the United States Navy—to its great advantage, ultimately.

Fire control, while fairly simple in principle, is complex in detail, and, as it is a progressive art, those details are naturally military secrets. Speaking broadly, the system replaces independent operation of each gun by team work for the whole battery, directed by the fire control officer from the top of the cage mast, 100 ft. above sea level. If this station is shot away in action, the control party shifts to the other mast, or to the conning tower, or, as a last resort, to the turrets.

The general method is: (1) The range of the enemy ship is found by the range finder and its bearing by the gyroscopic compass. (2) Two sets of these observations, with a known interval between, give the data required to compute the enemy's speed and relative course, and the rate of change of range. (3) Instrumental observations are checked by "spotting"—that is, observing the fall of the shell, which usually makes a splash about 200 ft. high, visible in a clear day for 15 miles.

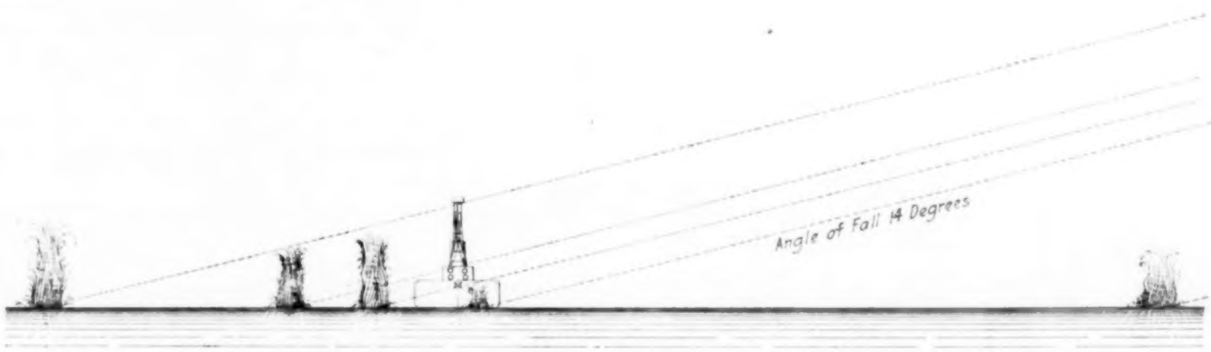
Now, no nation will attack us with any but a dreadnaught fleet, and only dreadnaughts can fight it. Hence, our naval strength lies fundamentally in the number and relative power of our dreadnaughts. At the beginning of the European war Great Britain had, built or building, 38 dreadnaught battleships, of which she has since lost one; similarly, Germany had 20, of which she has probably lost one; and the United States, 12.

As to dreadnaught battle cruisers: Great Britain had 10, of which she has lost 3; Germany, 9, but 3 have been sunk and one sold to Turkey; and the United States, none.

The relative dreadnaught strength of battleships and battle cruisers, based on pre-war figures and deducting losses, is, then: Great Britain, 44; Germany, 24; and the United States, 12.

No one outside of England or Germany knows what they have built or are building since the war started. There have been persistent reports, however, as to feverish energy in shipbuilding in both countries, and Germany has ample facilities for building at the rate of 25 dreadnaughts a year, while England could probably double this figure under stress.

So the United States has a hard road to travel to reach even second place among the navies of the world. It is true



Effectiveness of Salvo Firing of a U. S. Dreadnaught

(The extreme splashes are 400 yd. apart. In the position shown, three shots would have struck a battleship.)

that, since July, 1914, we have laid down 3 dreadnaughts, that the keels of 2 more will soon be laid, and that 4 more have been authorized for immediate construction. But it takes at least three years to build a battleship or battle cruiser, so that the last of the total of 16 dreadnaughts authorized by the recent Naval Appropriation Act will not be completed before 1922—at which time our dreadnaught strength will be 27, as against the pre-war strength, deducting losses, of 44 for Great Britain and 24 for Germany.

OUR NAVAL STRENGTH

The battleship has been the backbone of every fleet since navies existed. There is nothing else on land or sea which is its equal in the concentration of enormous power. The energy of one 14-in. shell is, according to Admiral Fiske, equal to that of 60,000 muskets. On this basis, the 12 guns of the battleship *Pennsylvania* are equivalent to the aggregate musket-energy of 720,000 men. Each of her 14-in. projectiles has a muzzle energy of 70,000 foot-tons. Under stress, her main battery of twelve 14-in. guns can be fired about three times per minute—a delivery of 2,520,000 foot-tons during that period.

Essentially, the dreadnaught battleship is, first, an all-big-gun ship—that is, it has a main battery of the same caliber throughout, whose guns are capable of piercing modern armor belts at battle ranges; second, it has a speed of 21 knots or more, so as to be capable of acting in company with other dreadnaughts; third, it has the maximum armor protection which is possible with this armament and speed. The battle cruiser is a modified battleship, having roughly about three-fourths the latter's armament and armor and about 50 per cent more speed.

And this is not all. A well-balanced fighting fleet includes cruisers, destroyers, and submarines, in addition to battleships and battle cruisers. The cruiser has two functions: First, the protection of commerce; second, as a scout and for general service with a fleet. In future fleet actions, if we shall not have enough battle and scout cruisers to force the enemy's screen and ascertain his strength and formation, our fleet will be blind and helpless. From all viewpoints an adequate increase in our cruiser strength is imperative, and this increase should far exceed what is proposed now by the Administration and Congress—not by naval officers who know our needs.

The question of destroyers is even more pressing. Primarily,

the destroyer's function is torpedo attack on an enemy fleet in battle. It can act also in protecting commerce and as a scout in moderate weather. But its surpassing service during this war has been in guarding Allied battleships from submarine attack.

England's pre-war proportion of destroyers to battleships was about 4 to 1, and this number she has found far too few as time went on. It takes five of them to convoy a battleship, and it took all she had at first to guard her Grand Fleet off the Orkneys, leaving her 1800 miles of coast line wide open for submarine attack on merchant vessels. To the British lack of these small, swift, and handy craft is due very largely her great losses of merchant vessels.

In 1922 our proportion of destroyers to battleships will be short by about 100 vessels of the British pre-war proportion of 4 to 1. Our deficiency with regard to the present proportion in the British fleet must be far greater. And yet, as the recent raid of the U-53 off Nantucket Shoals proves, we may need them in swarms on our 3000-mile eastern coast line. We might better lack a dreadnaught or an adequate fleet of submarines of our own than a strong force of destroyers.

As to submarines: The coast-defender type has shown its value during this war, and an adequate force of these vessels —not exceeding 800 tons' surface displacement and operating from protected bases—would worry an invading fleet seriously, and force it to make ceaseless attempts to trap or sink its under-water foes.

The fleet submarine — the large boat which, submerged, could charge with the fleet in action—is still but a dream. Her requirements are beyond the present state of the art. The ardent desire of every navy is to have such a vessel, with an engine exhaust which will not leave a white trail on the surface to betray her. She will surely come some day. Captain Simon Lake, the Nestor of submarine inventors, writes me:

"The high-speed submarine is going to come. How soon, I do not know. I do not believe anyone else can answer that question, as it all depends on the engines. Germany is, in all probability, away ahead of us in engine development today, but progress is being made, and as soon as we can get reliable high-powered engines, we shall have reliable high-speed submarines capable of accompanying a fleet."

ADMIRAL FISKE'S GREETING

When this paper was projected I wrote to a distinguished officer of our Navy, Rear Admiral Bradley A. Fiske—whose frank and fearless statements as to our naval unpreparedness stirred this country like a bugle-call—and asked him if, in view of the engineer's relation to naval war, he would favor me with a message to this great national body of engineers, through its representatives here assembled. In answer, the Admiral writes:

I am very glad indeed that you are going to address the American Society of Mechanical Engineers on "The Development of Our Fleet and Naval Stations."

There are no other men in the United States so immediately and directly powerful in developing the fleet and naval stations as the engineers. While the strategist estimates the general situation, and determines the application of the general principles of strategy to each situation as it arises; and while the tactician handles the units of personnel and material in actual battle and in preparation for it, it is the engineer who provides the strategist and the tactician with the mechanisms with which to carry out their respective and collective aims.

It is the engineer who enables the strategist and the tactician (and who often forces the strategist and the tactician) to keep his art abreast of the developments of the physical arts and sciences, and to take advantage of them. It is the engineer who has given to the world the gun, the torpedo, the submarine, the battleship, the wireless telegraph, the searchlight, and the aeroplane. It was the original military engineer—the youthful David, afterwards king—who made the first recorded triumph of science and art over mere physical strength, when, at a distance great in those days, he killed Goliath with his sling.

Therefore, for the reason that the engineers of any country have so much power to exert for the safeguarding of their country, and because men are always responsible for the power committed to their keeping, it is the high duty of all American engineers, and of you gentlemen who represent them, so to direct this power as to secure the peace and prosperity of the United States.

With respectful salutations to the Society, I am,

Ever sincerely yours,

(Signed) BRADLEY A. FISKE.

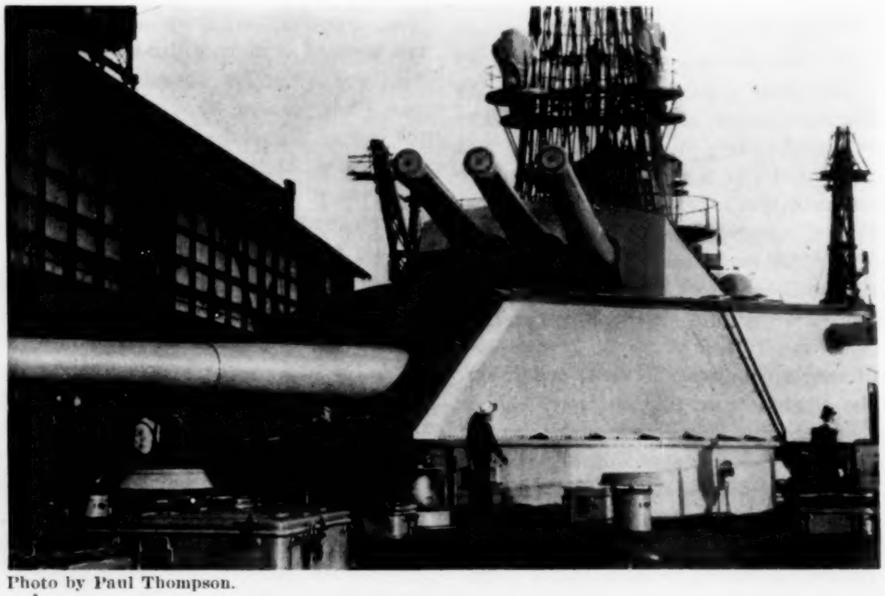


Photo by Paul Thompson.

THE ARIZONA'S QUARTERDECK, SHOWING HER TWO AFTER TURRETS, EACH MOUNTING THREE 14-IN. GUNS

VIBRATION IN TEXTILE-MILL BUILDINGS

By G. H. Perkins,[1] Lowell, Mass.

ABSTRACT OF PAPER

The author first states the nature of vibration in textile-mill floors and then enumerates the causes of such vibration, namely, unbalanced machines, heavily loaded trucks, weaknesses of building structure, poor soil conditions for foundations, and sympathetic vibrations originating outside the building.

He then discusses the objectionable effects of vibration in textile mills in regard to the security of the building, the quality of output of textile machinery, and also the nervous systems of the operatives. The methods usually employed in eliminating vibration in an existing building are stated, as well as the precautions to be observed when textile machines are mounted on rigid floors.

In the analysis of specific cases of building vibration, graphical records of the motion produced have proved of much value to the author, and he has accordingly included in the paper reproductions of several such records made by an instrument resembling the seismograph, together with particulars of the building in which they were taken.

It is the purpose of this paper to outline the principal causes and effects of vibration occurring in buildings occupied by textile-manufacturing processes, with the view of stimulating investigation and promoting discussion on a subject which has received but scant attention from those most vitally concerned. The importance attached to the question of vibration in many other fields of work is strongly emphasized by efforts made for its elimination from high-speed machinery, such as marine engines, steam turbines, electrical machinery and motor cars. Therefore, if vibration of a textile mill can be shown to produce any prejudicial effect on either buildings, machinery, product or employees, it would seem worthy of serious study. Information on this question must necessarily be of a fragmentary character, and nothing is here offered purporting to be a full analysis of the subject. The many and varied influences contributing to the resultant vibration of an entire mill building containing machinery in motion make the problem a complex one, and it is often impossible to even ascribe specific results to specific causes.

Vibration is unquestionably present in every textile-mill building to some degree, although its amplitude may be so minute that it passes undetected either by the senses or by any material effect. While most textile manufacturers will concede that vibration exists in certain parts of their plants, they are rarely convinced that any real damage is done, except when exaggerated or serious conditions affecting production make remedial action imperative. In many of our older mills, extraordinary conditions of vibration have existed for years without apparent serious results. Like conditions of production, except for vibration effects, are so rarely found and so difficult to create, that it is practically impossible to separate the losses due to vibration from those attributable to other causes, or to measure them in economic terms.

NATURE OF VIBRATION IN MILL FLOORS

The physical laws underlying the vibration of simple bodies, such as rods and plates, have been clearly defined and are well understood, but their application to the complex structure of a mill floor will not admit of any simple mathematical treatment. It is well known that all structures, simple or complex, have their inherent periodicity or rate at which "free" vibration will take place when they are set in motion, and that this period is dependent upon the mass, dimensions, and elasticity of the body.

In the textile mill, vibration most commonly results from the unbalanced resultant of forces set up by certain classes of machines, synchronizing to some extent with the natural period of the structure, or of one of its elements, usually the floor. From any evidence available it would appear that the actual movements do not agree, except for exceedingly brief periods, with the "free" natural vibration of the floor and are therefore of a "forced" character. This is doubtless a fortunate circumstance, so far as integrity of the structure is concerned, and cases are rare where vibration has been the direct cause of a building failure. The historic Pemberton Mill disaster occurred in a building noted for its freedom from vibration.

Two distinct classes of movements are commonly found in textile-mill floors:

a Horizontal movements of floor, more or less independent of walls, of comparatively low frequency and large amplitude. These may properly be classed as oscillations.

b Movements of higher frequency and less amplitude, often in a vertical plane, which may be considered as no more than tremors.

While vibrations may exist in all three planes simultaneously, they are under textile-mill conditions more apt to be strongly emphasized in only one direction. These motions may properly be considered as truly harmonic in character, and their period, frequency and amplitude defined as from a sine curve.

CAUSES OF VIBRATION IN TEXTILE MILLS

The principal factors contributing to vibration in textile-mill buildings are:

I Unbalanced machines, of which the following are the most important:

a Looms. The lay and pick motions of practically all looms are unbalanced reciprocating movements in a horizontal plane. Harness motions, including Jacquard heads, are reciprocating movements in a vertical plane. The frequency of these motions ranges from 90 to 180 picks per minute, depending upon type of loom and class of work.

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[1] Head of Textile Engrg. Dept., Lowell Textile School.

Presented at the Annual Meeting, December 1916, of The American Society of Mechanical Engineers. Pamphlet copies of complete paper may be obtained without discussion; price 10 cents to members, 20 cents to non-members.

b Noble worsted combs. The dabbing brushes are actuated by vertical reciprocating motions at from 1000 to 1200 r.p.m., with two brushes per machine. Cotton combers, on which the nipping motion oscillates at from 100 to 125 nips per minute, giving slight vertical throw.

c Mules. The carriage of a mule moves with a variable alternating motion in a horizontal plane at from 4 to 6 draws per minute.

d Unbalanced drums, cylinders, rolls and pulleys are frequent causes of local vibration. Worn or defective gearing also often causes trouble on heavy roll drives, as on calenders.

e Heavily loaded trucks moving over light floors cause deflection of beams and plank and some vibration.

II Inherent weaknesses in the structure, such as thin walls, light floors with long spans, and unsuitable connections between floors and walls.

III Poor soil conditions contributing to relative freedom of foundations and footings.

IV Sympathetic vibrations originating outside the building. These are frequently set up by water falling over dams, reciprocating engines in adjacent buildings, or by railroad trains. Their mode of transmission is often obscure, although it is sometimes direct, as through pipe lines or solid ledge.

VIBRATION RECORDS

In the analysis of specific cases of building vibration, graphical records of the motion produced have proved of much value. Such records showing the period, amplitude and cyclic variations of the vibrations serve as a guide in tracing their origin and assist materially in estimating the effects produced on building and machinery. Numerous instruments for this purpose, which need not be described here, have been constructed, involving the basic principle of the seismograph originally developed for the study of earthquake phenomena.

The partial records presented are portions only of results obtained in the course of investigations carried on under various conditions in textile-mill buildings. As it is obviously impossible to present any extended records, the purpose of the paper will best be served by confining the results shown to those obtained from one typical weaving mill.

Description of building:

Length, 270 ft. 0 in. Spans: 4 of 26 ft. each
Width, 116 ft. 0 in. 1 of 12 ft.
Basement, 10 ft. 6 in. Bays, 7 ft. 6 in.
Two Stories, 16 ft. each Roof of Saw-Tooth Type
Walls: 24 in. on first story, 20 in. on 2d story
Pilasters, 28 in. wide Windows, 5 ft. 0 in. wide
Floor Beams, 10 in. by 18 in. Floor Plank, 4 in.

Floor plans and arrangement of machinery are shown in Figs 1 and 2. Stations at which records were taken are numbered on floor diagrams. It will be noted that all looms are arranged across the mill and records show longitudinal vibration only. Records taken with instrument set transversely showed no appreciable motion on either floor.

Records taken in this mill after the installation of additional looms, indicated a decrease in the maximum amplitude, fewer cyclic variations and a somewhat higher average amplitude. (See Figs. 3 to 7.) The reduction in the maximum

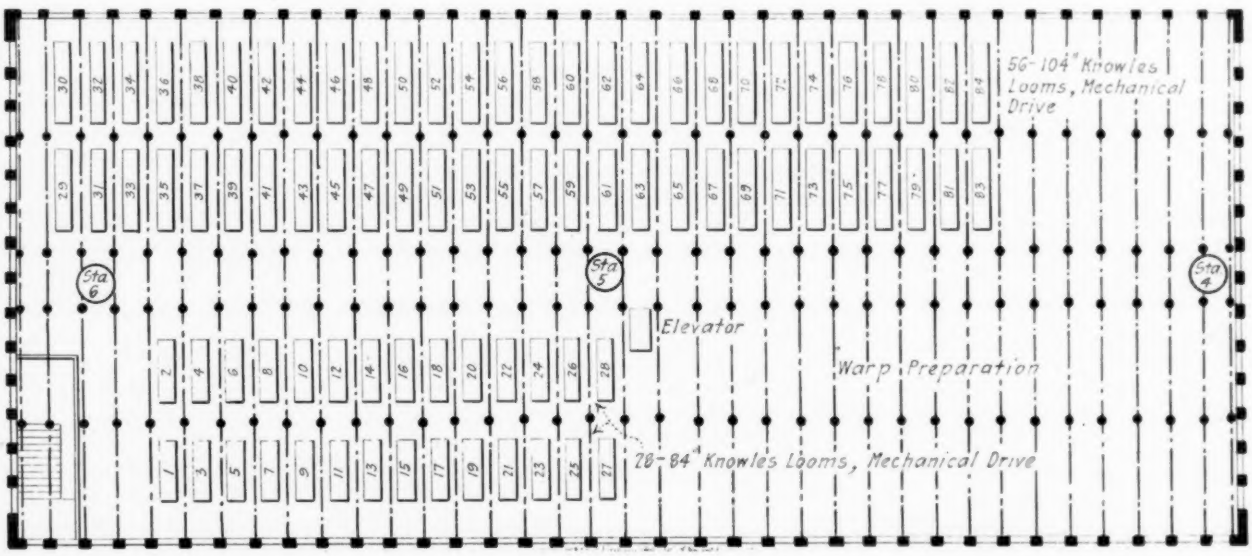


FIG. 1 FIRST-FLOOR PLAN

double amplitude was from 0.059 in. to 0.045 in. This is not an unusual experience when mills are equipped in installments. A mathematical analysis of the unbalanced horizontal force applied to the floor by a 72-in. Knowles worsted loom running at 120 picks per min. showed an average value of 154 lb., with a maximum of 262 lb. This gives some conception of the magnitude of the total force acting when a number of looms are in synchronism.

In all cases any movement estimated by the senses was far greater than actually recorded. This bears out the fact that even small and harmless vibrations are often responsible for apprehension on the part of the operatives.

EFFECTS OF VIBRATION

In presenting information covering the effects of vibration, the writer wishes to acknowledge the assistance rendered him by the Aberthaw Construction Company, of Boston, Mass., who deserve much credit for undertaking an extensive investigation of this unpromising subject. They have placed at the writer's disposal all of the interesting material accumulated by them to date, covering a wide range of industries.

Objectionable effects of vibration in textile mills have been noted by various observers as follows:

a Settling of foundations and footings on poor soils, with resultant cracking of walls and unleveling of floors, due to a "shaking-down" process of buildings subject to excessive vibration.

b Effect on operatives. This is usually manifested by apprehension of the failure of the building, loss of efficiency due to fatigue, and the serious effect of continued vibration on the nervous system.

c Effect on production of textile machinery.

Carding Wider card settings are found necessary on vibrating floors, causing uneven and poor work.

Spinning Vibration of ring rails on frames spinning either fine numbers or coarse waste yarns, causing breaking down of ends.

Turning of roving bobbins on skewers of spinning-frame creels, causing roving to unwind and kink.

"Chatter" of rolls on long frames.

Weaving Vibration of tension weights on narrow fabric looms, causing dropping of weights when loom is at rest.

Shaking of similar tension weights on elastic-webbing looms, permitting rubber warp to slacken and causing defective work by allowing excess elastic to enter fabric.

Increased sensitiveness of "feeler" mechanisms in filling changing looms.

Finishing Chattering of "doctor" blades on "back-filling" mangle, due to passing trucks, causing uneven distribution of starch on goods and imperfectly cleaned roll.

Wave movement of water in pan of "damping" machine, causing uneven distribution of moisture on goods by spraying brush.

Miscellaneous Breaking of electric-lamp filaments, making spring suspensions necessary. Difficulties in use of sensitive instruments, such as balances, scales, testing apparatus, etc.

Many consider that the matter of increased power consumption of shafting due to vibrating floors is important, but no authentic tests covering this point are available.

ELIMINATION OF VIBRATION

The elimination of vibration of an existing building of mill construction is usually attempted by:

a Stiffening and strengthening of floors by additional columns or trusses and making more secure connections to walls; also by stiffening outside walls with additional pilasters, or in the case of wooden-frame buildings even by braces or guys.

b Balancing of all machines possible and cushioning or absorption of the shocks of machines in which an unbalanced component seems unavoidable. More attention could advantageously be given to the matter of balance in certain classes of textile machines by their builders. Incidentally, the attendant reduction of noise would be beneficial.

The well-known advantages of reinforced-concrete buildings with particular reference to rigidity will not be discussed here, but such construction undoubtedly would obviate a large portion of the difficulties outlined above. There are certain conditions, however, where too great rigidity has been found to be most undesirable for certain classes of textile machinery as at present constructed. Such a large proportion of our textile plants occupy buildings of "slow-burning" mill construction that it is the present purpose to show existing conditions rather than emphasize the advantages of any one type of construction.

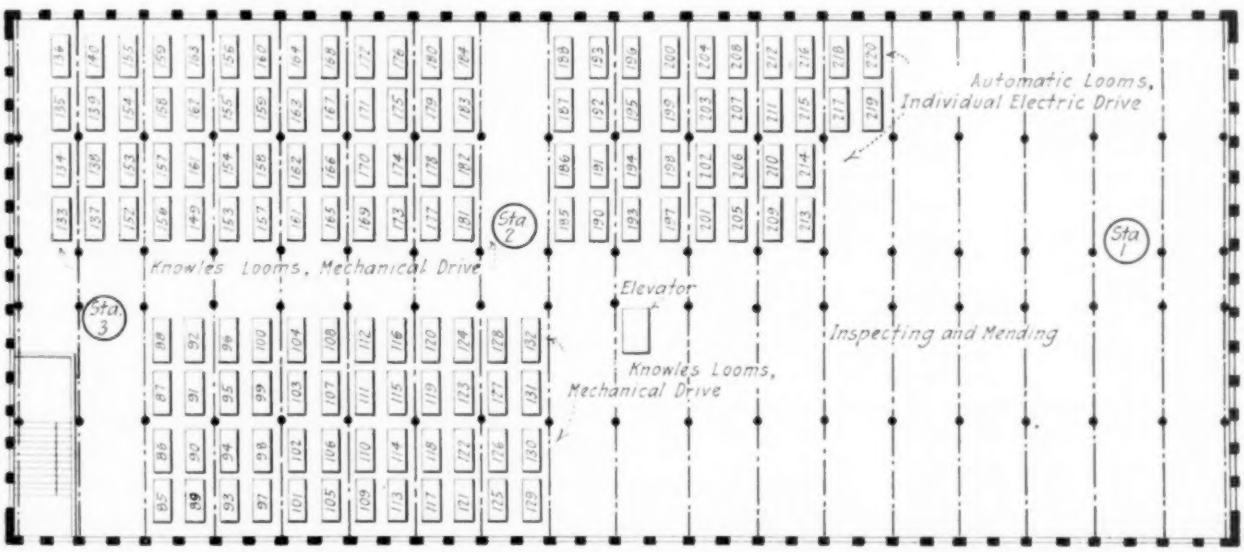


FIG. 2 SECOND-FLOOR PLAN

EFFECT OF RIGID FLOORS ON TEXTILE MACHINERY

The data available covering the comparative operation of textile machinery under similar conditions on rigid and flexible floors are extremely limited, but experience seems to emphasize the following:

a In weaving heavy fabrics, the breakage of loom parts has been excessive when looms are mounted on concrete floors with no provision for absorbing the shocks produced. Cushioning the loom feet with absorbents such as wood, cork or rubber, has been found absolutely necessary under these conditions.

b Transmission of the noise of machinery to offices, laboratories, etc., has been found exceedingly annoying in some concrete buildings.

NEED FOR FURTHER STUDY

The problem of mill vibration, while not new, has yet to receive either full recognition or sufficient serious attention. The resulting economic losses are unquestionably large, if analyzed from all standpoints, and the elimination of vibration is consequently an important factor in the efficiency of the plant.

All information at present available would seem to point to a general agreement as to the desirability of avoiding excessive vibration in manufacturing buildings. There is evidence of a growing interest in the subject, but the scarcity of authentic results from experimental work along this line, carried on under actual manufacturing conditions, makes exhaustive tests and observations necessary before any general conclusions can be reached.

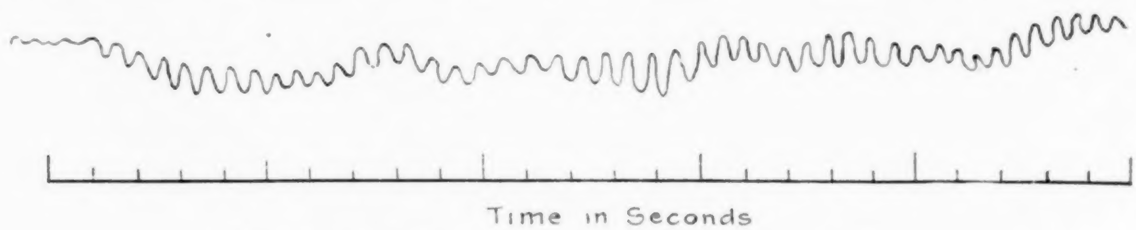


Fig. 3 Record No. 1, Taken at Station 3 on Second Floor
Shows High Average Amplitude. Period, 108 to 120 per Min. Average Loom Speed, from 110 to 120 Picks per Min. Maximum Double Amplitude, 0.03 In.

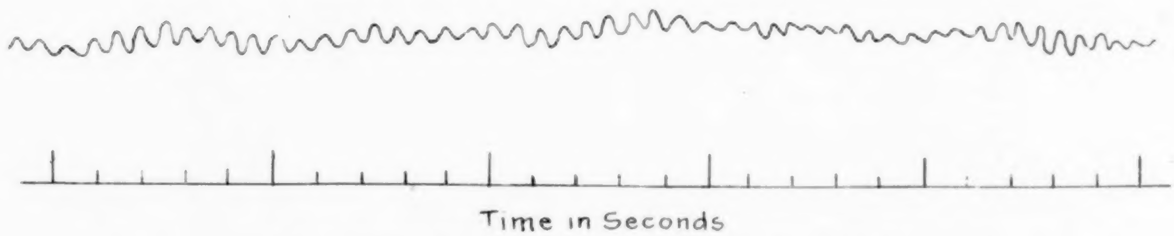


Fig. 4 Record No. 2, Taken at Station 3 on Second Floor
Shows Low Average Amplitude under Same Conditions. Records Taken at Station 2 Showed Same Characteristics as Those at Station 3

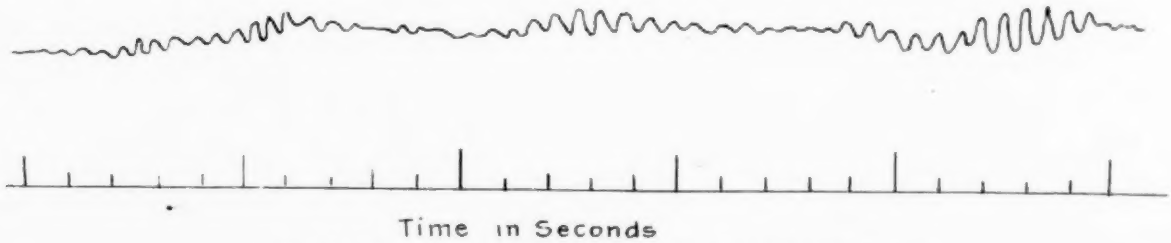


Fig. 5 Record No. 3, Taken at Station 3 on Second Floor
Shows Evidence of Cyclic Disturbances about Every 8 to 10 Sec.

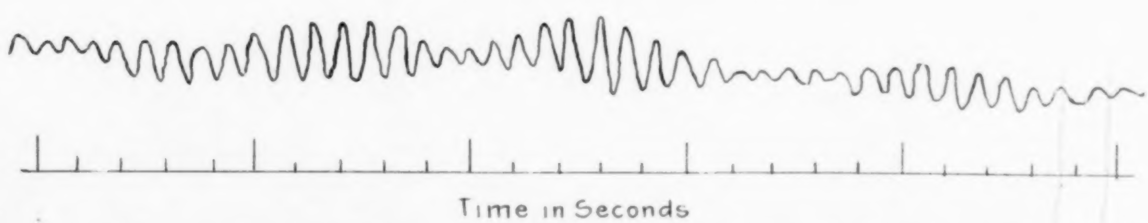


Fig. 6 Record No. 4, Taken at Station 1 on Second Floor, About 50 Ft. Away from Nearest Machine
Indicates How Readily Vibrations are Transmitted through Floor Undiminished in Amplitude. It may be Noted that the Group of 36 Looms Nearest to Station 1 are Individually Electrically Driven. Maximum Double Amplitude = 0.045 In.

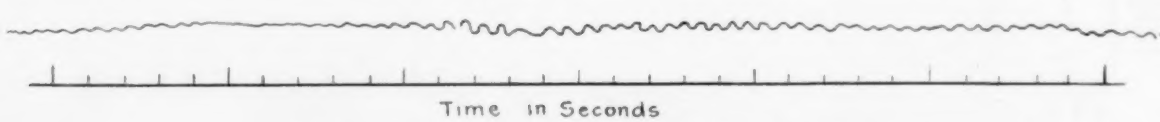


Fig. 7 Record No. 5, Taken at Station 5 on First Floor
Shows Typical Record at this Point with Vibrations of Slightly Less Frequency and Small Amplitude. The Average Speed of the 104-in. Looms on This Floor was 90 Picks per Min., and the Speed of the 84-in. Looms was 98 Picks per Min.

HOW DOES INDUSTRIAL VALUATION DIFFER FROM PUBLIC-UTILITY VALUATION?

By JOHN H. GRAY,[1] MINNEAPOLIS, MINN.

IT IS my object in this paper to show that value logically and necessarily means exchange value based on capitalized earnings, real and estimated. It depends on strategic advantages, and involves speculative elements, which are destroyed when an industry is declared a public utility and its earnings are limited to a fair return. This fair return has no relation to value, but is a matter determined in the supposed interests of the public welfare. The basic purpose of regulation is to limit profits to a just amount, and thus to take that part of the property for the public which would inure to the private owners under non-regulation. For the value of such an unregulated private monopoly is limited only by the willingness and ability of the people to pay rather than do without the services of the monopoly.

This paper deals chiefly with valuation of public utilities for purposes of fixing rates. As the courts ruled in 1898 that utilities are entitled to a fair return on a fair value of property in use at the time of valuation, valuation is necessary if regulation is to be attempted.

The most significant tendency of the last two decades the world over, and more particularly in America, has been toward the socialization of wealth; or, to express it in another form, toward the limitation of the rights of private property. Many businesses formerly considered private—gas, electricity, common carriers, insurance, banking—have now been brought under public regulation.

For better or worse, public utilities have been taken out of the category of unrestricted private property. Technically, they remain private property, but the law has taken from them the chief attribute of private ownership, that of the chance of speculative gains. The doctrine of fair return forever separates such property economically from ordinary private property.

For instance, it is only a single generation since the courts of this country uniformly declared that the making and distribution of gas was a private industry. The most conservative would not undertake to maintain that view today. The placing of electricity within the class of public utilities is much more recent. But, perhaps, no other industry illustrates this point as well as the common carrier and the extent of regulation, which, in theory, is universally recognized as proper today, compared with that which we considered permissible a generation ago. A mere study of the phrases "reasonable rates" and "unjust discrimination" will show the progress we have made, for good or for ill, along this line.

The same social progress has brought urban land, and in some countries all kinds of land, under special public control in every civilized country except America. What is true of land is equally true of the whole range of insurance. The changed attitude of the public mind towards the rights of banking illustrates the same point. A century and a half ago banking and insurance were, both, under the common law, occupations freely open to anyone, without restraint.

REASONS FOR CLASSIFYING CERTAIN INDUSTRIES AS PUBLIC UTILITIES

We have found that social considerations make certain industries of more immediate and overwhelming interest to the public welfare than are ordinary private businesses, and have thrown them into a single category labeled "public utilities"; but what social, economic and political reasons justify us in so doing?

About 150 years ago there grew up the theory that under a system of free competition one's self-interest would prevent him from injuring the public. With an abundance of free land, large opportunity to expand, accompanied by a high degree of intellectual, social, and educational equality, this was measurably true. But with the creation of fixed capital on a large scale this doctrine became unsafe, and self-interest can no longer be depended upon to hold in check the recklessness, greed and extortion of the owners of even purely private property. Government regulation may then be ascribed to the breakdown in the application of competition.

If competition, as indicated, is not a real safeguard, what is the danger of leaving private parties unrestrained in those industries where competition no longer works smoothly or effectively? I think if we go thoroughly into this point, we shall realize as never before that with the limitations of human knowledge the more complex the machine became, the more extended the division of labor, and the larger the mass of fixed capital, practically the more dangerous to the public was any mistake of the owners. If we wished to turn this into a modern phrase, we should say that it was strictly the speculative element in private property, the buying and selling and holding for an increase in price, that furnished the point of greatest danger. One was allowed this freedom in the early days on the supposition that the natural resources and things out of which property rights could be carved were virtually unlimited, and that when one undertook to develop these resources and claimed them for his own, he was doing a public service. Since we have found that resources are not unlimited and that we must learn to live together, we have discovered that, in this particular, what one gets for himself is taken from another, or at least prevents the other from taking in like manner and to the same extent. In other words, we are face to face with monopoly.

The world has now become alarmed on the subject of non-regulated privately owned monopolies, and there is a growing tendency to declare more and more of these to be public utilities. We apparently have reached the conclusion that civilization cannot be maintained or advanced unless such utilities can be made to render adequate service at a reasonable charge and without unjust discrimination. But increasing emphasis must be put on the fact that stability, regularity and universality of service are of infinitely more importance to the public than the general level of charges or the amount of profits made by a company.

SPECULATIVE ELEMENT IN PUBLIC UTILITIES THE ULTIMATE REASON FOR REGULATION

In the past the reason for the purchase of property has

[1] Professor of Economics, University of Minnesota.

Presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 1916. The paper is here printed in abstract form. Pamphlet copies of complete paper without discussion may be obtained; price 15 cents to members, 30 cents to non-members.

often not been merely for the sake of income, but for the sake of possible gains in selling. Whatever we may finally consider is justice in regard to the reckless, unsavory and speculative past in this field, we may safely say that the world has now come to the view that for all future investments the amount contributed by the owners shall be the basis of calculations for rates, and that variable risks shall be met by varying rates of charge and income rather than by fluctuations in the value; for so long as we have the latter, owing to false valuations, we shall have manipulation and speculation to bring about increased gains. Our present problem is how are we going to take conditions growing out of competitive circumstances and adapt them to an age of monopoly with as little friction and injury as possible, and, in working it out, we must never forget that speculation and regulation cannot simultaneously exist.

LIMITATIONS IMPOSED ON PUBLIC-UTILITY PROPERTY

We are here concerned with the meaning of the content of the term "property": what are, in fact, and what ought to be, the limitations, if any, on the absolute rights of property. Are the limitations on public utilities different from those on strictly private property, and are they more severe? There can be no doubt of the present tendency on this subject. It is all towards greater socialization of wealth and limitation of private rights. One evidence of this is the growing tendency towards public ownership and operation, and the public enjoyment of property shows this. The constant enlarging of the list of industries that are subject to more and more restrictions in the public interest clearly points in the same direction.

It is true that many such industries are comparatively new, but they existed for a relatively long time before they were classified as public utilities. For instance, the common carrier is old; and it took us a long time to realize that the parlor-car business, the pipe lines (gas and oil), gas companies, the telegraph, the telephone, fall into the same class because of performing similar functions, and, that, if left unregulated, they are capable of inflicting like monopoly injury and abuse. So we have progressed step by step from the common carrier through the utilities named to the street railway, the use of electricity in all its manifestations, to conduits, cold-storage warehouses and the like. Furthermore, we have recently entered upon a broad and wide field, with ill-defined limits, that comes neither within the realm of public utilities nor private property, as these terms have heretofore been used, but occupies what Mr. Bryan calls a "twilight zone."

Justice Brewer discusses such cases in the Kansas City Stock Yards case,[1] where he considers various industries requiring some special regulation, but not such as we impose upon public utilities. One cannot view the progress regulation has made, for good or for ill, without realizing that the emphasis on property rights has changed fundamentally in recent years. In the opinion of this generation, property either public, semi-public, or private is looked upon more and more as a public trust. The attitude of the public mind, and of the law, has not only changed toward the industries mentioned, but has changed towards the industrial trusts as well; hence our anti-trust laws. Recently we raised the question whether mere size is cause for added regulation. For an answer to this question we must wait for the Harvester case to be decided. The subject naturally shades off into pure-food laws, building ordinances, height of buildings, and so on.

THE FAIR VALUE OF PRIVATE INDUSTRIAL PROPERTY

The question of the fair value of a strictly private (industrial) property depends principally on what it will actually sell for. This is determined by the actual past earnings and an estimate of future earnings, the latter being based on a presupposed established rate of charge. If the property is not subject to effective competition, the only way of arriving at its value is to estimate what it would sell for under competitive conditions.

This argument rests upon the *laissez-faire* doctrine of competition. The idea of competition rests on the right of charging all the traffic will bear, and on the assumption that natural forces place a limit to charges and thus prevent extortion. In such cases no government regulation is necessary or desirable. Regulation is the very antithesis of competition. The necessity for regulation comes from the fact that competition is totally absent, or is ineffective to protect the public and keep charges within the bounds of reason and in harmony with the welfare of society.

I have gone into this long preliminary statement to furnish a proper background, or foundation for our discussion, and to show, also, that things are not as hard and fast as we have been wont to suppose, and that changes in our legal system, even without any changes in the constitution, are not so difficult as they have usually seemed to be. But let us now come back to the main issue.

HOW SHOULD A PUBLIC UTILITY BE VALUED?

Since the monopolies under question are not sold frequently enough under comparable circumstances to establish a market price, we estimate the value on the basis of capitalized earnings, and on the (legal) assumption that the existing rates are fair and just.

There is a legal assumption that the existing rates are just, because they have not been judicially called in question or proved to be unjust. Take, for example, the vexed and admittedly unsettled claim of the public to a share, at least, in the clear surplus of a company acquired out of earnings which have also yielded dividends at a fair rate. It is conceivable that the question might properly be decided one way in the case of a company going out of business, and in exactly the opposite way for a company compelled to continue to serve the public, or, one way in regard to a surplus acquired before the era of regulation, and quite another way in the case of a surplus accumulated under regulation. In the one case the rate from which the surplus came might be considered both legal and just, in the other as both illegal and unjust.

But all careful and disinterested students now recognize, notwithstanding great vacillation of the United States Supreme Court on the subject, that the necessity for this super-regulation arises solely from the fact that the industries now under review are monopolistic. It cannot be said too often that regulation is simply a substitute for competition.

Gains due to speculations, stock waterings, frauds, extortions, excessive charges, surplus and unearned increment ought not to be and cannot be allowed to go to owners of public utilities. Past claims ought to be compromised or adjusted in some way and a new start made on a sound basis. With a complete, amicable and final settlement of this question, all

[1] Cotting v. Kansas City Stock Yards, 22 Sup. Ct. Rep. 30 (1901).

would agree that all that owners of public utilities are entitled to in the future is a safeguarding of the money they contribute and an annual rate of income commensurate with the risk involved.

PUBLIC-UTILITY PROPERTY ENTITLED TO A FAIR RETURN

Public-utility property, being devoted to public use, must be content with a fair return, determined under our system of jurisprudence by public authority, with an ultimate appeal to the judiciary. It is liable for continuous service, additional investment may not be made without specific consent of the public, accounts must be kept and made public in reports, and the owner must serve all alike without discrimination. Ownership under such conditions of incumbrance is therefore but partial.

The novel theory has recently been put forth that public-utility property is not in fact dedicated to public use, but merely the service is so dedicated.[1] But this theory in view of all the facts seems scarcely tenable. Such a limitation amounts to the statement that the property as compared with private property is property affected with a genuine servitude or incumbrance. If one has incumbered his private property with a mortgage, he does not expect to enjoy as large a net income therefrom as if the property were wholly unincumbered. Just so, on investing in public-utility property one does so under the present law and practice of regulation, with full legal notice of this incumbrance of regulation. To this extent, and in this sense, he is not free to do as he pleases with his own if he professes the public service.

We must not lose sight of the fact that freedom of contract is at the very foundation of all property rights, and cannot in essence or in law be separated from property as protected by the fifth and fourteenth amendments and other constitutional provisions. Nor would I be understood to say, or even to imply, that these constitutional safeguards are of no significance in the case of public-utility property. The whole point of my argument, however, is, that, by declaring certain property affected with a public interest, we have thereby necessarily given such an interpretation to these constitutional provisions as seriously to incumber the property, and, therefore, have restricted the uses to which it can be put so long as it is dedicated to a public use.

VALUATION OF FRANCHISES

Under our system of law a secondary or local franchise is property, but it is not to be valued, in ordinary rate cases, unless there is some specific agreement or contract on this point that makes valuation necessary. Unless a franchise gives an exclusive right and carries an inviolable contract for a fixed charge, it is not to be valued in a rate case under the established principles of regulation. The general rule now is that in rate cases franchises are not to be valued above actual cost. This is plain from the mere fact that in a rate case the fairness of the present income is the point at issue.

Valuations are made today not because justice or economic policy require it, but because of the court ruling that property is entitled to a fair return on its fair value. What is a fair value? These industries are vitally necessary to us, and if left in private hands the estimated income from them must be at the normal rate in the community for investments accompanied by like risks, in order to attract the necessary capital.

In a rate case it is impossible to arrive at a valuation that has significance. Courts have tried in vain to qualify value by such words as "fair." If these words could be collated and disconnected from their speculative past, they would mean simply that a company is entitled, in view of the unregulated results of the past, to what the court, under all the circumstances, regards as an adequate reward for the services and capital the owners have wisely and efficiently contributed. This, however, has no fixed, permanent or measurable relation to value in an economic sense.

COST-OF-REPRODUCTION THEORY OF VALUATION

For a decade or more and until recently the so-called cost-of-reproduction theory of value actually dominated courts and commissions, but they now demand the facts of investment. Companies claim a value on the cost of reproduction as high as the public would be willing to give rather than forego the service and undergo all the inconveniences of doing without it until a duplicate plant could be built. They forget, however, that the public, in absence of specific contract, has a right to duplicate the facilities, and that this would greatly lessen, or even destroy, the value of the old plant.

The fact that in a majority of the older and stronger railroads and many other utilities the original water has been squeezed out by the investment of surplus earnings in the plant, does not simplify the problem of valuation but merely adds complications to it. It emphasizes all the more the speculative elements in the situation. In the earlier days, the companies claimed a return on all their watered stock, and opposed regulation that interfered with this claim. To this the court answered with its "fair value." The effort of the companies was to inflate the valuation so as to bring about the results that the court denied them in the case of Smythe *v.* Ames. Meantime, social growth was very rapid and regulation very lax. Therefore, when prosperity came, surplus was piled into the plants in addition to a fair dividend, and under the doctrine of valuation and freedom of contract the companies with such surpluses based their claim to these same old speculative gains—gains which may legally, if not wisely, be permitted to go to private property, but which the law of public utilities tried to prevent from coming into being, and, by its doctrine of reasonable rates, tries to claim a share in after they have been created. I am not, at this point, passing judgment on the question whether these speculative gains ought to be prohibited or not. I am simply trying to show that the idea of monopolies regulated by law, under the doctrine of public utilities, leaves no place for them. The main object of classifying any industry as a public utility is to prevent this very thing. But valuation under the cost-of-reproduction and similar methods now employed prevents the accomplishment of this object through regulation.

All our trouble with regulation comes from past speculation and not from an inability to agree about what is just and fair, so far as entirely new utilities and future investments in old ones are concerned.

RESULTS OF CURRENT VALUATIONS MISLEADING

The valuation of all the railroads now in progress, as well as current valuations in rate cases, are worth more than their cost as a means of educating the public, and may be highly profitable as a basis for compromising with the companies

[1] Jared How, Discussions of the Economic Club of San Francisco, vol. I, p. 44.

for their past efforts. But they do not arrive at value in the economic or market sense. They are misleading, for the public supposes that on the theory of the cost of reproduction the next time a rate case arises we must go all through the process again, and drag in all the speculative elements due to social growth, unearned increment, and the like.

It may not be out of place to call attention, at this point, to several relatively recent street-car franchises[1] based on the so-called principle of cost of service. These franchises are all in my judgment not only defective but vitally defective. But they are worth all they have cost and all they will cost in the future because of their contribution to the particular point under discussion. They have banished, once and for all, from these systems the bugbear of valuation; for the future the amount on which the companies are entitled to a return is the actual investment, or what is accepted as such by agreement.

These franchises are meant to give a fair return, in the future, on public-utility investments, made on a monopolistic basis, under non-speculative conditions, and publicly controlled capitalization.

Unless an attempt at regulating capitalization by commissions should prove as futile as earlier attempts at preventing stock watering have heretofore proved, investments made from now on will need no valuation whatever in these cities or elsewhere in rate cases. Furthermore, it seems plain that all commission laws will, in the future, provide for controlling investments and capitalization. It is not too much to hope and expect that the Interstate Commerce Commission will, at an early date, be given power over these matters.

This is what the new model franchises call for. It is what sound regulation means. It still leaves the vexed question of pioneering past wrongs and extravagant ventures to be settled by compromise, not by determining value in any proper or economic sense of the word. As previously stated, this is a matter of public policy, to be determined not by experts but ultimately by public opinion.

Any other method of trying to determine what is fair to the owners by valuation, or otherwise, plunges us at once into the question of how to deal with the results of past speculation, good, bad, and indifferent. How ought the punishments and the rewards of these past reckless, unregulated conditions of the competitive era to be apportioned between the owners and the public? What is a reasonable notice of a profound change of policy on the part of the government? There can be no doubt of the legal right of a government to change its policy and as little doubt of the fact that by creating the class of public utilities and making them subject to such regulation as the law calls for, we meant to change the relation of this property to government and to take away the chance of speculative gains. Is it fair then to enforce these laws strictly, or should we give more time for adjusting the old conditions to the changed ideas of public welfare? In other words, when ought we really to begin to enforce the theories underlying regulation? I cannot undertake to answer these questions at this time, but content myself with remarking that we have allowed the owners in their attempts to safeguard their supposed interests through valuations, to make control of future investment practically impossible, while contributing almost nothing to the settlement, under a compromise agreement, for the chaos of the past.

[1] I refer more particularly to the so-called street car settlements in Chicago, Cleveland, and Kansas City.

THE SURPLUS PROBLEM

If we could imagine all public-utility property now existing wiped out by a miracle, and all other things to remain as they are, namely, knowledge and needs, does anybody imagine that any question of valuation or "fair value" would or could arise? Under the present form of commission control, the commissions would simply see that the money with which to rebuild was properly capitalized, and the owners would agree that their returns ought to be based on this amount, and no other. Sound regulation aims at stable and equal rates much more than at low rates or low profits.

As for the claims of the public to a share of the surplus, the commissions would take charge of that at its source, and, under their control over investments, see to it that only such future surplus ever came into being as was really needed to protect the credit of the company and to carry on the business effectively. We should have no such a condition as presents itself today in the Union Pacific Railroad, which as a result of successful speculation now holds securities of other roads to the amount of $175,819,947; and in addition, a surplus in cash, and cash items, of $35,000,000. If the road never did any more transportation business or utilized any of its transportation property for any purpose, it could, from its other investments, pay a good dividend on its common stock in perpetuity. What relation has all this property to a fair rate? What is a fair valuation? What property ought to be included in a valuation of the property of this system?

Probably any system of effective regulation calls logically for a guarantee by the public against all losses necessarily incurred. It might be more advantageous to do this directly and openly instead of as at present inflating valuations under the heads of "going concern," "cost of developing business," etc.

CONCLUSION

To summarize: The welfare of the public has made it necessary to class certain industries as public utilities and to limit their profits. In the absence of regulation there would be no limit to the profits except the ability of the public to pay. Value, in the ordinary sense of the word, would therefore increase. The chief motive for regulation is to prevent such possible extortion by confining utilities to a fair and steady rate. This, however, destroys those attributes of private property out of which value grows. For value is measured by earning power, and this under regulation is fixed by law and not by the economic forces and bargaining power that fix value in the only proper meaning of the term. Therefore, to attempt to discover value as a means of fixing a rate of such a monopoly is to reason in a circle.

We have been led into this slough of despair in the wrangle over who ought to have the gains and who ought to bear the losses of the era of competition. With these questions settled once for all, there would remain no controversy over the fact that the amount so agreed upon plus any future additions is the investment upon which a fair return should be allowed. The present commission system of regulation, with its power over investments, capitalization and accounts, provides for such determination of the investment, and there is now no possible chance or occasion for valuation for rate making under such an arrangement, except as the controversy over the disposition of the speculative gains of the unregulated past and the uncertainty of the records of that period make it necessary as a basis for compromise.

REPORT OF COMMITTEE ON RECOMMENDED PRACTICE FOR STANDARDIZATION OF FILTERS

On January 28, 1913, P. N. Engel, Mem.Am.Soc.M.E., suggested in a communication that the Society appoint a committee to take up the question of rating of mechanical filters. Mr. Engel's suggestions were substantially as follows:

"Mechanical sand filters of the pressure type are coming into more general use every year, and yet the engineer or architect under whose specification they are bought and installed has no way of ascertaining just what size filters are needed to perform a certain amount of work, other than he can secure from the various filter manufacturers' catalogues, or from the claims of the filter salesman, which we regret to say in many cases vary greatly.

"Practically all of the standard filter manufacturers are agreed that a square foot of filter surface will not perform more in one filter than it will in another, with equal efficiency.

"I believe that the members of your Society will be greatly benefited by having an approved specification to which they could refer when buying filters, and therefore respectfully suggest that your Council appoint a committee to investigate the matter and to recommend the adoption of a standard specification.

"The points established are that the capacity of a filter is governed by the filtering area—that the filtering area is governed by the internal horizontal diameter of the filter; that all filters of a given diameter have the same capacity; that the capacities of filters of a given diameter vary according to the efficiency desired; that the more slowly the water passes through a filter, the more perfectly will the water be filtered, the minimum rate of flow being 2 gal. per sq. ft. of filter area.

"A standard specification will mean that the buyer of a filter of a given capacity will get a filter of the proper size—no matter from which manufacturer he buys it, and this is not the case at the present time, as the mechanical engineer has no text-book or standard specification to tell him what size filter is needed."

Mr. Engel's letter was referred to the Council, who in turn consulted a number of experts in this field on the desirability of the Society taking action in this matter. The consensus of opinion being favorable, the Council, on May 12, 1913, appointed the following committee to investigate and report on how to rate the capacity of mechanical filters: George W. Fuller, Consulting Engineer, *Chairman;* P. N. Engel, Vice-President, International Filter Co.; J. C. W. Greth, Manager, Water Purifying Department, Wm. B. Scaife & Sons Co.; James C. Boyd, Managing Engineer, Westinghouse, Church, Kerr & Co.; Wm. Schwanhausser, Chief Engineer, International Steam Pump Co.

For some time the work of the committee served to emphasize somewhat the importance of the conditions that led to its appointment, while at the same time developing difficulties in the way of making an adequate report.

The committee found, upon investigation, many points which undoubtedly needed remedying, it being doubtful whether pressure filters as used in the mill business or in the office-building business could be further standardized to approach the basis used in the best offices for municipal standards. The small pressure filters did not seem capable of having attached to them the various safeguarding devices used in the larger city plants.

On August 7, 1915, the committee lost by death one of its members, Mr. J. C. W. Greth, who rendered much aid in the collection of data on the practical side of the art. The chairman called in two new members, Arthur M. Crane, of the New York Continental Jewell Filtration Co., and Martin F. Newman, Assistant Manager of the Water Purifying Department, Wm. B. Scaife & Sons Co.

The committee presented its report to the Council on November 10, 1916, and it was received and ordered printed. The report was presented to the membership at the annual meeting in New York, December 5, 1916, and it was discussed at this meeting. The report and discussion are reported in full below.

The Report

To the Council of The American Society of Mechanical Engineers:

Your committee, appointed to make recommendations as to how to *rate the capacity of mechanical filters,* desires to submit the following report:

MUNICIPAL VS. INDUSTRIAL FIELD

2 The field of mechanical filtration may be arbitrarily yet definitely divided into two parts: One, the purification of drinking water or water for domestic supply, and the other the purification of water for other purposes, such as industrial uses.

MUNICIPAL PRACTICE SUBSTANTIALLY UNIFORM

3 On account of its importance and the large expenditure involved, especially in connection with municipal plants, much time and study have been given to all features of the filtration of water for domestic use. A large amount of data gathered through laboratory tests, and experience covering long periods in the practical operation of municipal plants, have brought into quite uniform adoption by all engineers engaged in such work the use of a rate of filtration of 2 gal. per min. per sq. ft. of filtering area for domestic supply.

DEPARTURES FROM NORMAL MUNICIPAL RATE PERMISSIBLE

4 While stating as a matter of information that such a rate is applicable in the great majority of such cases, your committee does not feel warranted in setting forth this rate as one to be adopted for all cases. As a matter of fact, the installation of a municipal filtration plant usually is done, and always should be done, under the advice and supervision of a competent filtration engineer engaged for the purpose, and the rate of filtration as well as other points of construction and operation should be left to his judgment, based upon the local conditions that may exist. For this reason, your

Received by the Council, November 10, 1916, and ordered printed. For presentation at the Annual Meeting, December 1916, of The American Society of Mechanical Engineers, 29 West 39th Street, New York.

committee feels that it is advisable and in accordance with the spirit and intent of your instructions to refer herein chiefly to the filtration of water for other than municipal purposes.

VARIOUS VIEWS CANVASSED

5 Your committee in considering this subject has sought information and assistance from many sources, and we desire herewith to express our appreciation of the many courtesies extended to us by those thus called upon for data or comment.

GRAVITY VS. PRESSURE FILTERS

6 It may be well here, in view of the misunderstanding that seems to exist to some extent, to make some reference to the two different types of mechanical filters known as the gravity type and the pressure type. With both types, purification is accomplished by passing the water through a filtering bed, which in practically all cases is sand, and the purification is dependent upon the property or power of the bed of sand to remove suspended impurities from the water passing through. This property is one inherent in the filter bed itself, and, while it will be affected by the rate at which the water passes, it is not altered by the incidental fact of the water being or not being under more than atmospheric pressure. While, with additional pressure available, more water can be forced through a pressure filter than a gravity filter of given size, there is no difference in the principles or methods employed that warrants a higher rate of filtration with such filters than is acceptable for open or gravity filters when similar results are to be obtained.

EXPERIENCE LEADING TO STANDARDIZATION

7 From the information gathered it was made apparent that experience has already brought about a substantial unanimity of opinion and practice on the part of all those who, as engineers, chemists or manufacturers, are brought into close contact with the field of mechanical filtration as to the limits within which permissible rates of filtration must fall. A very definite rate has become established in connection with municipal work, and indeed if there had been anything like the publicity in connection with filtration of water for other purposes that has obtained in connection with gravity filters such as are installed for municipal work, it is probable that there would have been no occasion for such investigation and report as this committee has been called upon to make.

TENDENCY TO OVER-RATING

8 While our investigation has made the above situation apparent, it has also developed the fact that there have been many filters installed in which the rate of filtration per unit of area is beyond, and sometimes far beyond, that at which good results can be expected or required. In some cases this has been due to the specifications under which the filters were installed, and in others, to what must be called an over-rating of the capacity of filters on the part of manufacturers. It is easily possible to force or pass through a filter of given dimensions much more water than it will properly filter, and in view of this it must be expected that there will be more or less yielding on the part of manufacturers placed under competitive conditions to the temptation to over-rate their filters.

NEED FOR DEFINITE, REASONABLE SPECIFICATIONS ON CAPACITY

9 This condition emphasizes the need and value of a pronouncement on this subject by some such body as The American Society of Mechanical Engineers which will serve for the information and guidance of those who, while having occasional need to specify or use mechanical filters, do not have opportunity to keep fully informed of conditions in that field. It is, therefore, hoped that this report and its recommendations will be of real value to engineers by placing before them information as to what is now the best opinion and practice, and thus enabling them to protect their own work and their clients' interests. To this end your committee most heartily and urgently recommends that when specifying filters there be included not merely the amount of water to be filtered per unit of time, but also specifications as to the rate of filtration per unit of area, or else the area or dimensions of the filter bed. Specifications thus written will insure fair competition and more satisfactory results.

IDENTITY IN GENERAL DESIGN

10 The same general design and the same principle of operation are followed by all the leading manufacturers of mechanical filters, the filtration being downward through a bed of sand superimposed upon layers of gravel, the filters being washed by a reverse flow of water. Competition in construction is, therefore, limited to the excellence of materials and workmanship, to the perfecting of details and to adaptations for convenience in accordance with good filtration engineering practice. While this affords abundant opportunity for conscientious care and requires familiarity with the history of filtration and thorough knowledge and observance of the results of experiments and tests, it does not allow any application of ingenuity to change fundamental requirements that are dependent upon natural laws.

UNNECESSARY TO STANDARDIZE CONSTRUCTION DETAILS

11 Your committee feels that it would be unwise, at least at this time, to attempt to standardize details of construction, there being a wide range in this field for individual preference or convenience, but there may well be established a standard in regard to the rate of filtration, since the object thereby sought is not mere uniformity but compliance with the limitations imposed by the laws of nature, so that the possible benefits of filtration will be actually and fully realized. It would thus seem to be self-evident, even if it were not fully established by experiment and experience, that the capacity of any filter is dependent upon and determined by two factors:

a The permissible rate per unit of area at which the water can be passed to insure the desired results.

b The effective area of the filter bed.

AGREEMENT AMONG LEADING FILTER MANUFACTURERS

12 It was made evident by the data gathered that there is a unity of opinion on the part of those best qualified to judge at what rate water may be passed per square foot of filter area to secure desired purification, and that there is a close agreement in the practice of all the leading filter manufacturers in rating the capacity of a filter.

FORM OF EXPRESSING CAPACITY

13 For convenience, we have expressed the rate of filtration in terms of gallons per square foot of superficial filter bed area per minute, thus combining units of quantity, area and time in a way to make easy the calculation of the amount of water any given filtering unit will properly handle or to estimate the area of filter bed surface that will be required for a given supply. The filtering area should be computed on the upper surface of the filter bed, as the latter lies during normal filtering operation, and no attention should be paid to a greater cross-sectional area such as is sometimes found in horizontal cylindrical filters.

CARE AS TO MAXIMUM DEMAND

14 In deciding upon the size of filters to be installed in any instance, very careful consideration should be given to the maximum flow that will be required at any time, and ample capacity provided. Where the demand is irregular, the maximum requirement is much greater than the average or minimum consumption, and either adequate storage for filtered water should be provided or the rated capacity of the filter made equal to the maximum demand. All filters are capable of passing more than their rated capacity, but beyond certain fairly narrow limits this is always at the expense of the quality of the filtered water, unless more than ordinary care is taken in efficiently coagulating the unfiltered water. As already intimated, the persistent use of moderately high rates above the normal and the occasional use of excessively high rates should be discouraged, if not prohibited.

DEPTH OF FILTER BED

15 While in a sense consideration of the filter bed may not be included within the instructions given your committee, we feel that some remarks in this connection will be of value, especially as there seems to be an opinion in some quarters that the use of a thicker filter bed or special methods or appliances for washing, or similar features, make higher rates of filtration permissible. In regard to such points, we would say, that while of course there is a minimum thickness of filter bed that must always be maintained for safety, better results do not follow increased depth. In fact, an excessive depth of sand bed is in some instances objectionable, as it may interfere with proper washing. We find that the minimum thickness of filter bed should be 27 in., of which at least 18 in. should be sand or similar fine material. A filter-bed thickness of 33 in., of which at least 24 in. is sand or similar fine material of suitable size and grade, is recommended.

INFLUENCE OF FILTER WASHING

16 While efficient washing of the filter bed must be provided for and while the use of special means or appliances, such as stirrers, air agitation or other means of breaking up the filter bed, may be of value in some cases as means of securing economy in time or of water consumed in washing the filter bed, the direct effect of such means is limited to that secured during the washing process and such effect has no influence one way or the other on the permissible rate of filtration, which is dependent upon and limited by properties inherent in the filter bed itself.

NORMAL FILTERING MATERIAL

17 The most desirable filter medium is a granular substance of a hard, non-porous, insoluble character, with grains substantially uniform in size and shape, the exact size and uniformity of the particles being open to some variation depending upon local conditions. If properly washed, such a filter bed will remain in efficient working condition for several years.

SPECIAL FILTERING MATERIAL

18 Bone charcoal or other porous material is sometimes of aid in the removal of iron, color, tastes or odors. But if they are used it must be recognized that growths of bacteria in the effluent are very likely to occur, although there is no evidence to indicate that such growths include disease-producing germs. These porous media may be used in single or double filtration, as noted in Pars. 20 to 23, inclusive.

RECOMMENDED RATE OF FILTRATION

19 The permissible rate of filtration in any instance depends upon the character of the water to be filtered and the purpose for which the water is used. If the water is for domestic purposes, whether the filters are installed in a municipal plant or otherwise, the rate of filtration should not exceed that which has been adopted for such service by universal consent of filtration engineers. We therefore recommend that:

a Whenever the water is to be used for domestic purposes or to secure full bacterial purification, the capacity shall be based upon a rate of filtration not to exceed 2 gal. per min. per sq. ft. of filtering area and a coagulant must be used.

b Where a lesser degree of purification is required, either because the water is not to be used for domestic consumption or because the water to be filtered is already sufficiently free from bacteria, or where the filtered water is to be effectively sterilized, a higher rate of filtration may be used, but not to exceed 3 gal. per sq. ft. per min.

DOUBLE FILTRATION IN SPECIAL CASES

20 Your committee finds that there is a limited use made of double filtration; that is, the water is passed through two filters placed in tandem. The consensus of opinion of those consulted and the recommendation of your committee is that when both filters are filled with the same medium this is not the best practice, but that better results will be obtained from the same filters operated in parallel, if they are properly constructed, owing to the slower rate of filtration.

21 Double or tandem filtration may, however, be used to advantage under some special circumstances, as, for instance, where the filter medium in the second filter is of a very close texture, so as to secure the very highest quality of filtered water by removing fine suspended matters that may pass through an ordinary filter bed.

22 Double filtration may also be of advantage where the use of a coagulant is not desired or where it is intended to remove iron, color, odor or taste. In such cases sand can be used in the first filter and bone charcoal or similar porous medium in the second. Such practice, however, should be limited to cases where an increase in the numbers of harmless water bacteria, such as frequently occurs in the effluent of a porous filter medium, is not objectionable.

23 If double filtration is employed, the rate of filtration should not exceed the rate of single filtration, unless warranted

by the results of experiments or upon the advice of a competent filtration engineer.

STERILIZATION

24 In earlier years it was frequently the custom to sterilize filter beds with steam, but it was found that the benefit of this treatment was temporary, and it frequently resulted in the growth of water bacteria within the filter. At present, sterilization is normally and preferably secured in the filtered water through the aid of liquid chlorine, hypochlorite of lime, or ultra-violet rays. When properly applied, such treatment will destroy all objectionable bacteria.

PREPARATORY TREATMENT

25 While this report deals essentially with filters themselves, it is proper to point out that mechanical filters, with the rapid rate of filtration employed, cannot be expected to accomplish the best obtainable results without the securing of proper coagulation; and if the raw water is very turbid, then preliminary sedimentation also must be considered.

26 In closing this report the committee desires to express its deep loss in the death on August 7, 1915, of J. C. W. Greth, Mem.Am.Soc.M.E., one of the original members, and also its appreciation of his aid in collecting data on the practical state of the art and of his judicially expressed opinion as to the basis of this report.

Respectfully submitted,

GEORGE W. FULLER, *Chairman*,
JAMES C. BOYD,
ARTHUR M. CRANE,
PHILIP N. ENGEL,
MARTIN F. NEWMAN,
WILLIAM SCHWANHAUSSER,
Committee on Filter Standardization.

DISCUSSION

JOS. W. ELLMS.[1] The recommendations of the committee making this report are in agreement with the best modern practice in the design of mechanical filters. They have quite clearly indicated the maximum limits for safe rates of filtration and the minimum depths for the filtering medium. Their conclusions on these points are in accord with the writer's own experience.

In declining to commit themselves in regard to construction details, they are probably justified; yet it might have been well to have enunciated some of the general principles which experience has shown to be essential to the best design. The writer has reference more particularly to underdrain, strainer and waste-trough design. Probably no portions of a mechanical filter are more directly dependent upon proper coördination than are those whose principal functions relate to the cleansing of the filter bed. So far as these portions of the filter act as distributors of the influent water to the filter bed, and as outlets for the effluent from the bed, their importance is only of a secondary character.

It is of the utmost importance that the underdrain system of a filter bed shall effect as uniform a distribution of wash water as possible. Whether this is done largely through strainers of various types or through perforated pipes, or in conjunction with the coarse filtering material forming the bottom of the filter bed, is of small consequence, so long as it is actually accomplished. Moreover, a uniform and speedy withdrawal of the dirty wash water by means of properly disposed waste troughs is as essential as uniform distribution of the wash water when entering the filter bed. In other words, a mechanical filter which cannot be quickly and effectively cleansed is defective.

It is to be hoped that the indorsement of the committee's report by the Society will establish certain definite principles of filter design to which manufacturers will conform, and by which purchasers of filters may be guided in judging of the merits of any particular design that may be submitted to them.

GEORGE A. JOHNSON.—The report of the committee recommending certain standard procedures in filter practice shows clear evidence that the general proposition has been viewed from the numerous necessary angles and the tentative conclusions drawn from approved practice in filter design and operation. At best the preparation of such a report was a difficult task, for the reason that in water-filtration problems local conditions govern so very largely, and their individual peculiarities are so numerous and varied. This report will serve a valuable purpose in the development of standard practices where possible of application, and the committee is to be congratulated for the skill and conservatism displayed in its preparation.

[1] Filtration Plant, California, Cincinnati, Ohio.

Frederick Schreibman, in the first of a series of articles in *The Iron Age* on improving operating conditions in machine shops without buying new machines or erecting new buildings, proposes to adopt the following plan whenever an expansion of a plant is attempted: *a*, to adopt a new location of machines at present used; *b*, to change the location or enlarge certain doors, windows, stairways and elevators; *c*, to strengthen certain parts of the first floor, etc.

In the construction and insulation of refrigerators "built in" on board ship, difficulty has been encountered with the use of cork that had not been sufficiently pressed previous to baking. This cork was not as dense as it should have been, and was lacking in mechanical strength.

As to refrigerator doors, the idea seems to prevail that they should have beveled edges and that such edges make a very tight door. However, as soon as the moisture begins to have its effect, such a door cannot be tight any more. Further, if the hinges yield at all, as they are likely to do with such a heavy door, it will never be tight.

The way to make a tight refrigerator door is to have a plain surface come up against a plain surface with a flexible gasket between them, or two pairs of such surfaces with gaskets between them, making an air pocket between the two sills. If this arrangement is used the door can sag considerably without causing any serious binding or failure in tightness.

As regards estimating the capacity of the refrigerator machine required to take care of the given refrigerator, it is not sufficient to calculate on heat loss through the insulation of the refrigerator, as it is only a part of the total loss. The other losses are due to heat entering in warm goods, by the interchange of air through the opening of doors, and by leaks through defective insulation or defective doors; to lights, or to the heat of the bodies of workers; to any change of state occurring in the goods, such as freezing, fermenting, etc.—R. F. Massa in paper at the Annual Meeting of the Society of Naval Architects and Marine Engineers, November 1916.

ANNUAL MEETING DISCUSSIONS

Written Discussions of the Papers Presented at the Thirty-Seventh Annual Meeting of The American Society of Mechanical Engineers, New York, December 5 to 8, 1916

In the preceding issue was given an outline of the Thirty-Seventh Annual Meeting of The American Society of Mechanical Engineers, held in New York, December 5 to 8, 1916, in which it was aimed to give a comprehensive and yet not over-long account of the whole meeting. It was only possible to include in this outline the briefest abstract of the written discussions, which were exceptionally full.

It was hoped to give full publication to these written discussions in this issue of The Journal, but here again space precludes giving more than one-half the discussions and the remainder will be given next month.

The discussions are printed substantially in full, and will be found to contain a large amount of valuable material supplementing the subject-matter of the papers. Following the discussions are given, in each case, the authors' closures, which refer also to the oral discussion abstracted last month.

THE TESTING OF HOUSE-HEATING BOILERS, L. P. BRECKENRIDGE AND D. B. PRENTICE

William Kent. The method of rating a house-heating boiler proposed by the authors seems to leave out a most important factor of such a rating, viz., the grate surface, or the amount of coal that should be burned per square foot of grate surface.

The authors say, "The capacity or commercial rating of a heating boiler has always been given in terms of the direct radiating surface which it would serve." The capacity of such a boiler thus defined, that is, the amount of radiating surface which it will serve, is an exceedingly variable quantity, depending chiefly upon the amount of coal that is burned under it per hour, which in turn depends on the size of the grate and the rate of combustion. A certain boiler with 1 sq. ft. of grate and say 20 sq. ft. of heating surface may supply 150, 300 or 450 sq. ft. of heating surface, depending on whether the coal is burned at the rate of 4, 8, or 12 lb. per sq. ft. per hour. It is evident then that no satisfactory rating of a house-heating boiler can be made that does not take into consideration the rate at which the coal is burned. I therefore would amend the authors' definition of a unit for stating the capacity of a heating boiler so as to make it read as follows:

The *foot of radiation* shall be ¼ lb. of steam per hour condensed at 212 deg. fahr. and discharged as water at 182 deg. (equivalent to 250 B.t.u. per hour) when the coal is burned at the rate of 4 lb. per sq. ft. of grate surface per hour.

I use the figure 250 instead of the authors' 242.6 because it has long been used by heating and ventilating engineers as a standard equivalent for an average square foot of radiation. A radiator generally discharges its return water at a temperature somewhat below the temperature of the steam, and the figure 250 is therefore more nearly equivalent to the actual conditions of condensing ¼ lb. of steam than is 242.6.

In 1909 the writer presented a paper on The Testing and Rating of House-Heating Boilers to the American Society of Heating and Ventilating Engineers, which is published in the Transactions of that society. Some of the points in that paper are pertinent to the discussion of the present paper.

S. B. Flagg and R. L. Beers. The writers have been engaged during the past two years in planning and carrying on an extended series of tests which the Bureau of Mines is conducting for one of the Government departments. The principal purpose of these tests has been to obtain information as to the relative value for domestic heating purposes of a large number of fuels used by this department, including a number of Canadian and foreign coals. At the same time a comparison is being made of steam and hot-water boilers.

The reasons given in the paper why it is important to have a satisfactory method of testing house-heating boilers are heartily indorsed. The writers would add to these reasons by pointing out that in many localities anthracite coal is practically unobtainable or can be used only at a much greater heating cost than for some other fuel. Consequently methods of firing and testing such boilers and the ratings established for them should take account of these other fuels, especially bituminous coal.

It is agreed that the lack of clearness as to the meaning of *a foot of radiation* is undesirable and should be corrected. In reporting results of tests of boilers of the hot-water type, the employment of a unit such as the paper describes would be especially desirable for comparison with steam-boiler tests.

In the development of plans for the tests which the Bureau is now conducting the following considerations governed:

The average residence-heating boiler operates during the most of the heating season at a load less than 40 per cent of its rating. Results were desired showing the comparative values of the fuels under average load conditions, and the tests were therefore run at approximately this load.

Conditions of attention were to be comparable to those in actual service so far as possible. For this reason with most fuels charges of relatively large size were fired so as to give a firing period ranging from 6 to 12 hours.

In the case of the steam boiler installed in a residence, neither the rate of delivery of steam nor that at which the condensation returns is uniform. The boiler output was therefore allowed to vary, but the valve controlling the delivery was so set that with automatic damper regulation an average load of approximately 40 per cent of rating was maintained. This corresponds with the authors' requirement in Par. 12*a*.

So far as possible the test data were mechanically recorded and some of the data so recorded by a second piece of equipment.

In order to reduce errors of starting and stopping the duration of the tests was made approximately 48 hours.

The authors concede that when the load is allowed to vary the conditions of house operation are reproduced, but they feel that under such circumstances it would be difficult to duplicate results. Tests conducted at the Bureau's experiment station do not justify such a conclusion, and the writers' opinion is that the real purpose of the test should be to learn what the boiler will do under operating conditions. If it be agreed that such is the purpose the effort should be to approximate the operating load. Observations taken at the time the Bureau's plans were being developed showed that the actual delivery of steam by a residence-heating boiler varies

through a considerable range, even in moderate winter weather, and is affected principally by the times and conditions of firing, and the character of the fuel.

It was the effort when the Bureau's tests were first started to employ a method of starting and closing tests similar to that proposed in Par. 17 of the paper. The duration of the full test was then and still is made approximately 48 hours, and at the end of the first 24 hours the fires were brought to a closing condition and readings taken. Experience with this method, particularly with anthracite coals, showed so great variations between the two 24-hour periods and also between different tests that it was abandoned for what was formerly known as the "standard" method of starting and closing. With the latter method of test the overall efficiencies are usually lower, but results can be more easily checked with 24-hour tests by this method than by 48-hour tests by the former method. The following results illustrate the variation:

Test	Coal	Method of Starting	Duration (hours)	Total Coal per sq. ft. Grate	Overall Efficiency %
761......	Anth. Egg.	First.	47.07	89.6	77.6
761(*a*)...	"	"	24.28	51.8	80.0
761(*b*)...	"	"	22.78	37.8	74.5
868......	"	Second	24.25	80.3	62.8
853......	"	"	49.37	128.3	62.9

The proposed method of starting and stopping can probably be used with a fair degree of success with anthracite coal of stove or chestnut size, but the writers' experience with other sizes was anything but encouraging. The evaporative performances quoted by different manufacturers, nearly all of which are believed to be for anthracite coal, appear high, and it may be due to the effort to get results with a short test or to the use of a method of starting and stopping which does not give correctly the quantity of fuel actually consumed.

It is obvious that the proposed method of starting involves less work in both the conduct of the test and the analysis of fuel and refuse samples than does the other method wherein the test is started with a new fire and analysis is made of the material remaining on the grate at the close of the test. It was because of this difference that the effort was first made to start with a fire which has been burning for 3 or 4 hours, but the writers were not able to carry out the method successfully with anthracite, lignite and some of the sub-bituminous coals, and they are of the opinion that others would experience similar difficulty. A duration of test sufficient to show a total fuel consumption of 40 pounds per square foot of grate is, however, believed to be adequate if the so-called "standard" method is used.

The feeding of water to the boilers may be done as described in the paper or it may be done in another way if the output rather than input is measured. The latter course is followed in the Bureau's tests.

Connection may be made by a small line from a source of water under pressure to the return outlet of the boiler. In this line a small orifice may be placed and the pressure drop through the orifice read off of a manometer graduated to read in rate of flow or simply in pressure difference. The manometer shows at any time at what rate the water is being fed, and this feed can be adjusted to keep the boiler water level practically constant.

Measurement of output can readily be made in either of two ways. One way is to send the steam delivered by the boiler through a closed-type feedwater heater, the condensing water circulating in the coil, and measure the condensate. The other way, which would obviate the use of calorimeter readings in computing results, is to measure the quantity and rise in temperature of the condensing water, the condensate returning to the boiler. Selection of equipment for either method may be made from a wide variety, and nearly any desired degree of accuracy obtained in measuring the output.

Roy E. Lynd. There are two points in this paper which I would like to discuss. The first is that the titles of the paper and of the proposed testing code both confine themselves to house-heating boilers, and the paper states that the class of boilers indicated by the authors under this heading includes only boilers designed to serve 2000 ft. of radiation or less. It seems that we make a mistake in thus limiting this code. The same boilers which we use in our houses are used very extensively to heat schools, churches, and other large buildings, and several makes of low-pressure cast-iron sectional boilers are designed to serve as much as 10,000 ft. of radiation. We would do well to eliminate the term *house-heating boilers* from the title, the paper and the code, and substitute therefor *low-pressure heating boilers;* and include all low-pressure heating boilers instead of those only which are designed to serve 2000 ft. of radiation or less. The larger boilers of this class are covered by section (9) of the code, which states that the test conditions should be as nearly as possible like the ordinary operating conditions for the boiler to be tested.

In the A.S.M.E. Boiler Code of 1914, boilers are divided into two classes,—Power Boilers, Section 1, and Boilers used exclusively for Low-Pressure Steam and Hot-Water Heating and Hot-Water Supply, Section 2. This division should be borne in mind in any new testing code. As the proposed testing code is essentially a code for evaporative tests, we are not concerned with boilers for hot-water heating and hot-water supply. It would seem therefore that the new code should cover all boilers used exclusively for low-pressure steam heating, and should be so entitled. The A.S.M.E. Boiler Code, in Section 2, does not limit low-pressure heating boilers to 2000 ft. or less, and we should not so restrict the testing code.

The second point is in regard to the definition given for a *foot of radiation.* The authors seem to think that the amount of steam condensed per foot of radiation enters more largely into ordinary heating calculations than the B.t.u. They have assumed a convenient average amount of steam per foot of radiation, and have then converted this into an awkward B.t.u. value. This, to my mind, is wrong. We figure practically everything in connection with heating installations in B.t.u.'s, and it is very rare that the question of the amount of steam involved is raised. I would suggest that the *foot of radiation* be defined as a transfer of heat equal to 250 B.t.u.'s per hour. This figure, and its reciprocal, 0.004, are both very convenient, and would be far preferable to the figures given by the authors.

It has been the writer's practice to test low-pressure boilers at atmospheric pressure, keeping a record of the steam temperature as indicated by a mercury thermometer placed in an oil well directly in the steam chamber in the top of the boiler. The pressures at which these boilers are operated are as a rule so nearly atmospheric, if the heating system is conservatively designed, that a test made at atmospheric pressure comes about as close to actual operating conditions as it can be got. The great advantage of the atmospheric pressure test is, of course, its simplicity, it being unnecessary to use the reducing valve, receiver, and bank of valves spoken of by the authors.

One of the functions performed by this system of pressure control suggested by the authors is in the determination of the time of starting and stopping the test. The test is started

by establishing normal running conditions with a pressure of, say, 5 lb. on the boiler. Then the fire is cleaned and thinned until the pressure drops to say, 3 lb., when the test is assumed to start. The same conditions are reproduced at the end of the test, the test being over when the pressure drops to the same 3 lb. This would all be out of the question with a test made at atmospheric pressure. The writer has used for some time a system which is very similar, and which gives practically the same accuracy, and which is applicable to tests made at atmospheric or any higher pressure. Normal running conditions are established before the test, and then the fire is cleaned and thinned just as outlined in the paper, but instead of depending on the pressure dropping to a certain starting pressure, the temperature of the flue gases is used as an index. When the temperature of the flue gases falls to a predetermined point, the test is assumed to be started, and at the close of the test the starting conditions are reproduced until the flue-gas temperature taken at the same point in the flue falls to the starting temperature. This method seems preferable, as the flue-gas temperature is more intimately connected with the condition of the fire than the steam pressure is, and at the same time it enables us to use the very much simpler atmospheric pressure conditions.

It has also been the writer's practice, for some time past, to keep accurate records of the draft in the flue, in the firebox, and in the ashpit, by means of differential draft gages. These data sometimes indicate differences in the draft conditions which may explain differences in test results.

Max Friedlander. Below is a description of a new method for the *continuous* determination of the heat balance of house-heating boilers. The principle of the method was suggested by Prof. H. Junkers, the originator of the Junkers calorimeter, and the method was tried out and applied by the writer in 1911 when he was his assistant at the Technical College of Aix-la-Chapelle, Germany.

The idea was to measure all items of a complete heat balance in a continuous way during operation, and for this purpose the boiler was suspended upon a sensitive balance, so the smallest amount of fuel burned off in the boiler could be weighed very exactly at shortest intervals, thus giving a continuous determination of the fuel consumption and the incoming heat. The arrangement is shown in Fig. 1.

The entire steam generated was condensed in a condenser and the condensed water carried back to the boiler. In this way the useful heat could be determined continuously by continuously measuring with a Poncelet vessel the quantity of cooling water used in the condenser and, with the thermometers, the increase in its temperature.

The flue gases were drawn out by a ventilator and carried through a flue-gas calorimeter, in which their entire *sensible heat* was determined by cooling them down to the room temperature by a water jacket, the quantity of cooling water being measured continuously with a Poncelet vessel, and its rise in temperature also being measured. The volume of the flue gases was recorded with a gas meter of 1500 liters capacity per revolution.

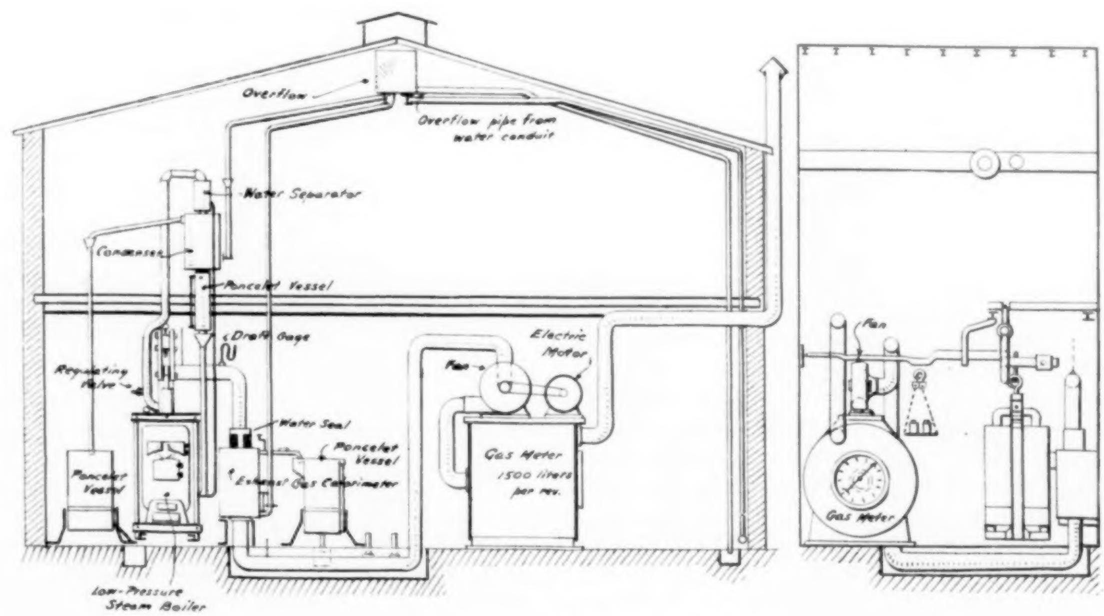


Fig. 1 Testing Low-Pressure Boilers at the Royal Technical High School, Aix-la-Chapelle, Germany

A quite novel feature was the continuous determination of the loss of heat due to incomplete combustion by a new calorimetric method in which the heat value of the flue gases was measured in a calorimeter fitted with a specially designed burner for which a patent is pending. This method for the calorimetry of flue gases has been developed by the writer in separate experiments and tried out in a great number of actual tests and applications on boilers and combustion engines, and it has been described in detail in a dissertation (not yet published), where all these experiments and tests are also reported. The arrangement for this is also shown in the illustration.

The heat loss due to incomplete combustion was very variable and, with the boiler mentioned, wavered between 8 per cent and 23 per cent of the incoming heat when the operation and combustion was normal, and increased to over 45 per cent when the boiler was operated with insufficient excess of air or otherwise in bad condition. In all cases, however, the heat value of the flue gases decreased continuously, or, in other words, the combustion improved steadily in the proportion

as the layer of coal was burning off, thus indicating that the boiler was working in the beginning like a gas producer.

Heat radiation and conduction was determined by temperature measurements of the outer surface of the boiler and its surroundings, and by use of individual coefficients of heat transfer.

CLOSURE BY PROFESSOR BRECKENRIDGE

L. P. Breckenridge. The authors appreciate the discussion and suggestions presented by the different members. It is evident that the time has arrived for adopting a plan for testing house-heating boilers. It is probable that the Power Test Committee will be able to use the suggestions made in the discussion when they come to give consideration to this paper.

At no place in the paper do the authors discuss a method of rating boilers. That is a matter for future consideration. We still believe that in spite of the convenience of 250 B.t.u., the reason already given in the paper is of sufficient weight to justify asking that the most careful consideration be given to the authors' proposed definition of a foot of radiation.

THE UTILIZATION OF WASTE HEAT FOR STEAM-GENERATING PURPOSES. ARTHUR D. PRATT

Warren B. Lewis. The extraction of waste heat from furnace gases has not always been successful, and the unfortunate examples have been heralded fully as much as the successful ones. Boiler economizers are the most widely known waste-heat extractors; and their success has been due, in no small measure, to a thorough understanding of the characteristics of the gases to be handled. The conditions surrounding steel furnaces have not been so thoroughly understood, nor the requirements of the furnace so well appreciated, so that the apparatus for recovering waste heat has not been standardized.

The following description of a plant using waste-heat boilers in which the transfer rate is low is cited to show what has been accomplished from a different reasoning point to that employed in the paper.

Admitting at the start that mechanical draft is practically a necessity, the regulation of draft takes place in the flue between the furnace and the boiler, or, to put it another way, a certain definite draft must be maintained at the end of the checkers. What happens beyond that point is of comparatively small importance.

The furnaces were fired with producer gas made from bituminous coal. The amount of coal consumed in a year was 8400 tons. The gases between the producers and the furnaces were analyzed, as were also the gases between the checkers and the stack; and a determination made of the weight of gas issuing from the stack. The temperature of the gases averaged 1050 deg. fahr., and the boilers were designed to abstract 550 deg. fahr.

The boilers chosen were of the Manning type, with tubes 20 ft. long; and draft was produced by means of a motor-driven steel-plate fan mounted on a platform at the top of the boilers. A rotatable steam-jet tube blower was installed, by means of which the tubes could be blown out as often as desired with a minimum of labor. The ground space occupied was small, and the protection necessary from the weather inexpensive. The boilers were equipped with automatic feed-water regulators.

The early calculations in connection with this installation showed that there should be an average output of 212 boiler hp. One year after the investigation was made the boilers were in operation, and the actual boiler horsepower developed was 227; the temperature of the flue gases was 418 deg. fahr. The total square feet of heating surface was 6600, and the transfer rate less than 2. The actual power required to drive the fan was about 2½ per cent of the net return from the boilers.

The tests showed a comparatively high percentage of recovery, as indicated by the low temperature of the flue gases issuing from the fan.

In order to recover a high percentage of heat with a low transfer rate, a large amount of surface must be used; and it is simply a question of what that additional surface costs as compared with the cost of a high-pressure drop.

L. D. Ricketts[1]. The Cananea plant is the oldest one installed with the header type of flues for the distribution of the waste-heat gases to the boilers. In more modern smelters in the Southwest, Stirling boilers or ones of similar type but of much larger capacity are used. They are equipped with superheaters. Economizers have not been installed recently on account of their tending to become foul and to cut down the draft in the furnaces.

The new plant of the International Smelting Co., near Globe, Arizona, has three reverberatory furnaces, each 21 ft. wide by 120 ft. long, and seven waste-heat boilers of a capacity of 713 boiler hp. each, and they are supplied with superheaters which furnish 50 deg. of superheat to the steam, which is generated at a pressure of 195 lb.

We find it advantageous, however, to use three boilers to a furnace, and now that we have to increase the size of the plant and add an additional furnace, we contemplate installing three more boilers of this size so that we can do this in operating three furnaces and have one boiler as a spare.

It may be of interest in this connection to give some idea of the amount of power recovered at a plant like the one in question.

Each of the furnaces treat about 500 tons of solid charge per day, and with two furnaces running continuously the plant smelts about 30,000 tons of solid charge per month. The evaporation from and at 212 deg. in the oil-fired boilers in the power house is 16.46 lb. of water per pound of oil. The evaporation in the reverberatory furnaces is 7.32 lb. of water per lb. of oil. In other words, a pound of oil burned for smelting purposes in the reverberatory furnaces yielded on an average (for the first ten months of 1916 at the International Company's plant) 44.77 per cent. of the power such oil would yield if burned under its boilers. The gross oil consumed in smelting was 0.856 barrel per ton of solid charge, and of this 0.475 barrel was charged to smelting and the balance to steam generated.

B. N. Broido[2]. Waste heat is also very often used in Germany to superheat steam. In cases where for some reason superheaters cannot be installed in boilers, or in which circumstances require the superheater to be near the engine, independent superheaters are recommended. In such cases superheaters heated by waste gases are the ideal installation.

The writer has designed and installed a number of superheaters both large and small for waste heat. Fig. 2 shows such a superheater for 40,000 lb. of steam per hour, installed at the plant of the Coal Mining Co., Gelsenkirchener Berg-

[1] 42 Broadway, New York.
[2] 228a Rector Street, Perth Amboy, N. J.

werks Gesellschaft. The gases had an average temperature of about 1382 deg. fahr.

The moist steam enters the superheater at *A* in order to prevent rapid burning of the tubes at the point where the gases first come in contact with them. The steam flows through this portion of the superheater in the same direction as the gases, passes over to *B* and flows in the opposite direction, taking full advantage of counter-flow principle.

With a velocity of the flue gases of about 900 ft. per min., and a velocity of steam inside of the pipes of about 5000 ft. per min., the average heat transfer was 4.3 B.t.u. per sq. ft. per deg. fahr. temperature difference. The steam for this superheater was supplied by five waste-heat water-tube boilers, 300 hp. each, four of which were always in operation.

On account of its smaller heating surface the cost of this independent superheater was considerably smaller than it would be with each boiler provided with its own superheater.

Most of the superheaters have been installed for waste heat from coke ovens and open-hearth steel furnaces. Also copper furnaces and cement kilns often furnished waste heat for superheaters.

have been in accordance with early rather than modern waste-heat practice; that is, gas velocities comparable to those now used in open-hearth, cement-kiln and beehive coke-oven work have not been used. In view of the success of the application of this principle in these industries, and from a comparison of exit-gas temperatures from boilers set with smelting furnaces and temperatures from the modern design of waste-heat boiler, it would certainly appear that a trial installation at least of the modern design is warranted on the part of one of the copper campanies.

Mr. Lewis in his discussion gives some interesting figures on the performance of a boiler with low-temperature gases where, based on the transfer rate, the velocity must have been very low as compared to modern waste-heat-boiler velocity. He points out that for such low transfer rates the amount of surface to be furnished for a given capacity must be high. The boiler in question, presumably of 660 nominal rated horsepower, cooled approximately 48,000 lb. of gas per hour from 1050 to 418 deg. and developed 227 hp., or some 34 per cent of its normal rating. It is interesting to compare the heating surface of a modern waste-heat boiler to develop the same

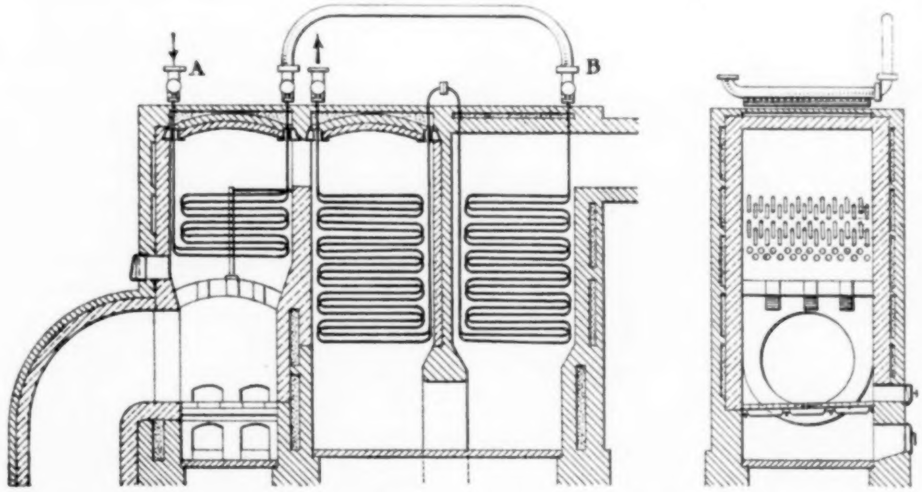


Fig. 2 Independent Superheater Utilizing Heat of Waste Gases. Capacity, 40,000 Lb. Steam per Hour

MR. PRATT'S CLOSURE

Arthur D. Pratt. Mr. Christie raises the question as to whether the principles of high gas velocity could not be successfully applied in direct-fired work. This has been tried a number of times, and the absence of unqualified success has come rather from improper boiler design than from faulty principle.

It is of interest to note that there have recently been sold a number of direct-fired boilers in which the principle of high gas velocity along the lines of modern waste-heat practice is followed. These units are not as yet in operation, but in view of the knowledge gained in waste-heat work there is no reason why the installation should not be wholly successful. That this view is warranted is best indicated by the boilers described in the section of the paper on Utilizing Beehive Coke Oven Gases. Here with entering gas temperatures of 2100 to 2300 deg. fahr., temperatures which at least closely approach the direct-fired practice at ratings of 200 per cent and upward, exit temperatures of about 475 deg. are secured.

The operating figures of the International Smelting Co. given by Dr. Ricketts are of interest. With one exception, all of the boilers furnished with copper reverberatory furnaces

capacity with that described by Mr. Lewis. With such a boiler it is entirely possible to cool this weight of gas from 1050 to 418 deg. and thus develop 227 hp. (It is to be remembered that the temperature to which it is possible to cool a gas is to an extent governed by the pressure carried in the boiler.) The amount of heating surface necessary for such capacity, however, would be approximately 3500 sq. ft. as compared with 6600, and this heating surface would be operating at some 65 per cent of its normal rated capacity.

Mr. Lewis states that the power required to drive the fan was approximately 2½ per cent of the net capacity of the boiler. With the gas velocity through the boiler corresponding to the transfer rate obtained, the draft loss through the boiler proper must have been very low, and it is possible that the duty of the fan consisted largely in furnishing draft at the checkers. If the ordinary draft of 1.4 in. was required at the checkers, with the furnace directly connected to a natural-draft stack, the height necessary for a gas temperature of 1050 deg. would be approximately 150 ft. With the boiler installed and the gases cooled to 418 deg., this height of stack will give at the boiler outlet about 0.75 in., which would not be sufficient for proper furnace operation.

As compared with $2\frac{1}{2}$ per cent of net power required for the fan with the boiler described, a motor-driven fan for the modern design of waste-heat boiler would require approximately 4.4 per cent of the gross output. A turbine-driven fan for the modern unit would require approximately 6.4 per cent of the gross output, but if the exhaust from the turbine could be used in a heater, a large part of this power could be returned to the system.

While, as Mr. Lewis states, the question involved is the cost of additional surface as compared with the cost of a high-pressure drop (for a net capacity), the foregoing comparison seems to be decidedly in favor of the modern design.

Mr. Broido's discussion, in which he refers to the utilizing of waste heat for superheating steam, brings out a point that was perhaps not sufficiently emphasized in the paper, namely, that by far the greater portion of modern waste-heat boilers installed have been equipped with integral superheaters. The high gas velocity has the same effect in increasing transfer rates in superheaters as in boilers, and the amount of superheat being obtained even with low-temperature gases is comparable to what would be secured from the same amount of superheating surface in direct-fired boilers.

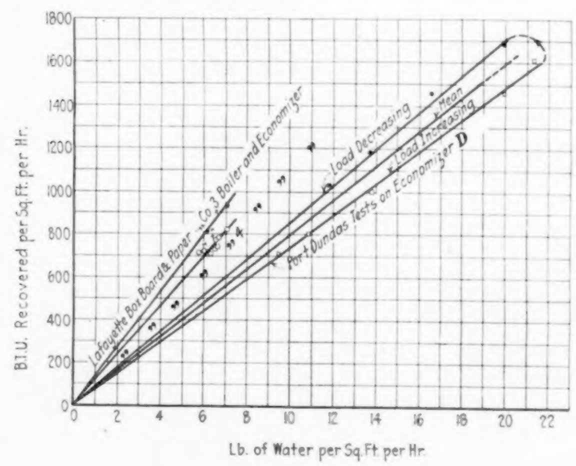


FIG. 3 RELATION OF HEAT RECOVERY OF AN ECONOMIZER TO RATE OF WATER FLOW

Several installations have also been made of superheaters outside the boiler proper after the manner of separately fired superheaters. In one plant with which the writer is familiar such superheaters were set in the flue connecting open-hearth furnaces to waste-heat boilers. In these superheaters a transfer rate of approximately 6 B.t.u. was obtained.

In one or two other installations superheaters have been placed outside of the setting in the exit boiler flue. Such a location, however, would only be practicable with boilers where the gas velocities were such as would result in high exit-gas temperatures.

GRAPHIC METHODS OF ANALYSIS IN THE DESIGN AND OPERATION OF STEAM POWER PLANTS, R. J. S. PIGOTT

C. F. DIXON. We are building in Buffalo a station which will be equipped with three 20,000-kw. Curtis turbine generators and five 11,500-sq. ft. B. & W. boilers and Green economizers. We placed in operation on November 26 one turbo-generator and two boilers. Our operation is in conjunction with Niagara power, so that the steam plant is in operation now only about twelve to fourteen hours a day, and we are confronted with the problem of starting and stopping these large units from no load to full and reverse on very short notice. The starting is quite simple, as the underfeed stoker responds very rapidly to load demands. Our chief difficulty is in the loss of auxiliary steam during the starting period before the main unit is started. This is the only period I have ever found where electric-driven auxiliaries would show any value, and this period does not extend over 20 to 30 min., and would never occur in a 24-hour plant.

Stopping these large boiler units is the most difficult problem we have, especially with the high volatile coal used. We have found that banking with green coal is out of the question. We are able, however, to take our boilers out without loss of steam if we have 20 min. to burn down fires before load is withdrawn.

I cannot agree with Mr. Pigott's statement that the economizer has grown undesirable through the use of higher boiler pressures. With higher boiler pressures have also come higher boiler ratings, with their consequential higher flue temperatures, and the economizer can be made to pay for itself under these conditions. The construction, however, must be materially changed for the higher pressures.

F. A. WARDENBURG. In this paper Willans input-output lines are ingeniously applied to the design of the power plant. In the paper two examples are worked out, where most exact information on each unit is plotted. It is not possible to secure such accurate data except from actual test on an operating plant, and in very few cases are these data available in making a design. There is no advantage in working out a design so minutely when the figures ordinarily obtainable are speculative. A great many things vital to the design of a power plant are not subject to exact analysis and must be left to the judgment of the designer; this being the case, it is straining a point to apply such exact analysis to the parts of the design for which figures of more-or-less doubtful value are available. Further, the proposed method does not take into account return on investment, which is one of the most important considerations in the design of a power plant. The designer can, by direct figuring, determine the necessary features of design more easily than by the use of the Willans input-output curves.

MR. PIGOTT'S CLOSURE

R. J. S. PIGOTT. Several who have discussed this paper seem to have mistaken entirely the source of the data on these curves. The method is practically without use if the data must be plotted from tests; in neither case were any test data available at the time the graphic curves were made up. They are made entirely from guarantees, and the data are no more exact than is usually the case in obtaining guarantees, except in that they are complete; but the use of the input-output line allows one to get the complete characteristics of a unit from two or three guaranteed points. This is especially true of such apparatus as boiler-feed pumps and fans.

The criticism that this method cannot be made to take care of financial features is not true; in one case in the paper I have done it, and it is just as easy to treat the investment costs in the same manner by the use of the double panel curve used by Mr. Stott when figuring total cost of power. If Mr. Wardenburg's statement about direct figuring being easier than the graphic method were true, there would be no necessity even for such things as load curves, because they can

always be figured from the log sheets. I do not believe that anybody who has made extensive use of graphics would agree with this.

With regard to Mr. Dixon's and Professor Greene's questions raised relative to the economizers, I would say that if the use of the steel-tube unit were adopted, most of my objections to the economizer in its present form would disappear; but in this paper I have been considering constructions as they are standard on the market at the present time. Certainly the reliability of the economizer would approach that of the boiler, if put into steel-tube form.

Mr. Reinicker's method is simply a short cut permitted in an operating station, by the presence of venturi meters. Naturally, advantage should be taken of the opportunity to elide some of the steps. I must repeat again that the paper is a mere indication of the application of the method. The variations in detail and in general are endless. To sum up, the use of input-output lines, both of individual apparatus and combinations of apparatus, is the easiest and safest way of getting information for all loads. Individual calculations for a single point at a time do not show the important changes taking place around cut-in points, and are not as likely to be accurate.

POWER-PLANT EFFICIENCY, VICTOR J. AZBE

Geo. H. Gibson. The author states that "it is difficult to reason out just what effect load variations have upon an economizer as a heat absorber." However, in a given installation, if the heat absorption at any one load be known, the heat recovery at other loads will be approximately in a direct proportion to the rate of water flow, as indicated by the chart of Fig. 3, which gives the results of three different tests with variable loads. From the Port Dundas test, it would appear that the heat recovery while the load is increasing is somewhat less than while the load is decreasing. This is due to heat storage in the large mass of water in the economizer. If the heat recovery of the economizer for a given steady load is known, however, it is only necessary to draw a straight line through this point and the point for zero load, in order to determine the heat recovery at every other load.

One of the graphs in the paper purports to show the relation between velocity of gas through the economizer and heat absorption per square foot per hour per degree difference of temperature. However, the coefficient of heat absorption varies with the temperature of the gases as well as with the velocity. The relations between rate of gas flow, temperature of gases and average coefficient of transmission are shown in the accompanying chart, Fig. 4, which I have compiled from tests upon a large number of commercial economizers in various conditions of actual service. The temperatures marked upon the graphs are the mean temperatures of the gases, that is, the temperature of the gases entering the economizer plus the temperature of the gases leaving the economizer, divided by two. The rate of gas flow is stated in pounds of gases per foot of pipe in a section per second, that is, if there are ten pipes in a section of the economizer and each pipe is 10 ft. long, there will be 100 ft. of pipe per section, and the total gas flow per second would be divided by 100 to obtain the quantity set off on the horizontal axis.

Ed. A. Uehling. Mr. Azbe's paper covers the whole steam-power plant, and he makes many valuable suggestions as to how the heat now wasted could be saved. I shall confine my specific remarks to the operation of the steam generators, in which at least 50 per cent of the preventable heat losses occur, especially in the type of plants to which Mr. Azbe most particularly refers.

To obtain highest efficiency from a boiler three things are necessary, these in the order of their importance being (1) efficient combustion of the fuel, (2) efficient absorption of the heat generated by combustion, and (3) efficient rate of driving.

The difficulty in maintaining boiler efficiency is that so many continually changing variables are involved in its operation that fixed adjustments are out of the question. To maintain maximum boiler efficiency the fireman must have before him the information necessary to enable him to make the required adjustments intelligently, as well as the facilities necessary to make them. The draft must be varied to burn the coal necessary to produce the steam required. The steam gage tells him when to increase or decrease his draft. The thickness of the fire must be adjusted to the draft, so that complete combustion takes place with the minimum excess of air. Unless some means are provided by which the fireman can tell whether the relation between the draft and thickness of fire is right, he cannot know with any degree of certainty

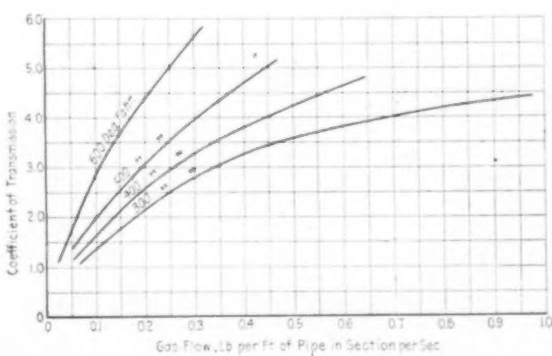


Fig. 4 Relations Between Rate of Gas Flow Through Economizers, Temperature of Gases, and Coefficient of Heat Transmission

whether his fire is too thick or too thin for economic combustion at the changed rate of driving. A CO_2 indicator at the boiler front tells him at a glance whether this adjustment is right, and what to do to make it so. Although the necessary draft adjustment to the steam demand and the fire adjustment to the combustion-efficiency demand can and must be made regardless of what the draft gage may indicate, it is none the less of great value to the fireman in making adjustments. He should have before him not only the boiler draft but also the furnace draft, the latter to indicate the condition of his fire bed and the former to indicate the rate of driving. Where positive information is required regarding the rate of driving, steam meters also must be installed.

The temperature of the escaping gas depends on four variables: (*a*) the condition of the boiler setting, including the baffling; (*b*) the condition of the heating surface; (*c*) the rate of driving, and (*d*) the percentage of CO_2 in the escaping gas. It is an index to absorption efficiency provided condition (*a*) is perfect and (*c*) and (*d*) are known. It is of no value to the fireman as a guide to combustion efficiency, because it depends on conditions beyond his control. A record of the temperature of the escaping gas considered by itself is also of questionable value to the operating engineer and may be entirely misleading, inasmuch as a low gas temperature may result from air infiltration as well as efficient absorption of heat by

the boiler, and high temperature may be due to a high rate of driving, dirty heating surface, or broken-down baffling. To discriminate in the former case, we must know the percentage of CO_2, and to locate the cause of the latter we must know the boiler draft.

Although the flue-gas temperature by itself is of no value to the operating engineer as a control, it becomes of some value when considered in combination with the boiler draft, and is of the utmost value in connection with the percentage of CO_2, because these two factors determine the heat loss up the chimney.

Boiler efficiency can be correctly ascertained only by accurately measuring the heat input and heat output. This, however, is neither feasible nor desirable under operating conditions. A system of efficiency control on the heat input-output basis was organized by Mr. Polakov for the Penn Central Heat & Power Co. in their Warrior Ridge plant, and described by him in a paper read before the Society in December 1913. This system of control approached scientific accuracy and gave excellent results, at least while under Mr. Polakov's able management, but it is too elaborate and cumbersome for general application, and to my knowledge has not been duplicated at any other plant.

Automatic coal weighers alone are of no value as a control for boiler operation, though they may be of some value as a check on the shippers' weights. Water meters are of more value because a more-or-less approximate estimate of the coal burned can be made at convenient intervals, perhaps monthly, and knowing the weight of water evaporated, a calculation of steam produced per pound of coal burned can be made and a rough idea of the combined efficiency of all the boilers obtained.

Diagnosis must precede the selection and application of the remedy, or a cure cannot be effected with any likelihood of success. Every boiler must be treated individually. The gas must be analyzed, temperatures must be measured and draft conditions observed continuously. To do this the necessary instruments must be supplied by the manager and intelligently used by the operating personnel, and if so used the highest efficiency which the conditions of the plant permit can be attained, and in no other way is it attainable. It has been accomplished many times by thorough combustion experts with the aid of an Orsat apparatus and a portable draft gage and pyrometer. This is very well and good. The trouble is the high efficiency established by the expert will not stay put. He has scarcely left the plant when it will begin to drop off, and in the course of a few weeks or months at most it will be down nearly, if not quite, to where he found it. High efficiency cannot be continuously maintained without instruments that will guide the fireman as to what to do, and will indicate properly the effect of what he did, and will autographically record the performance of both fireman and boiler as a control for the operating engineer.

Autographic records to be of the greatest benefit must be regularly and thoughtfully scrutinized and co-related, and the information they contain must be promptly acted upon, whether to bestow a praise, administer a rebuke, or correct a shortcoming in the operator or plant. The moral effect of the autographic record is very great if wisely used. Scientific apparatus cannot serve their purpose unless they are kept in continuous operating condition. They will not prove a paying investment if they are operated perfunctorily. They should receive the same regular and conscientious attention that must be given to the machines and apparatus which are vital to the operation of the plant.

MR. AZBE'S CLOSURE

Victor J. Azbe. In connection with Mr. Pigott's opinion in regard to maximum CO_2 desired, I wish to say that this is altogether a matter of type installation. With many installations it is not desired to go over 10 per cent; with others again 16 per cent and 17 per cent can be obtained without serious losses due to incomplete combustion. The most important factors in this problem are proper facilities for gas mixing and proper air distribution over the grate. We also must not forget that on one hand at high CO_2 percentages, CO might not be the only combustible gas escaping, and on the other hand that a given percentage of CO at high CO_2 percentages represents a great deal smaller loss than with the low CO_2.

Supplementing Messrs. Harrington and Polakov's excellent statements, I wish to say that while the manager is the one who is mostly responsible for the present condition, nevertheless the operating engineer shares also the blame to a very great extent, and the chief reason for the bad condition is that efficiency in power plants is taken, generally, too lightly, and this even by a great many professional men who really should be the leaders in agitation for better conditions.

I do not agree with Mr. Hunter's statement on CO_2 recorders, for the reason that I have had five CO_2 recorders of three different types in operation for two years, obtaining with them the most satisfactory results in our two St. Louis Anheuser-Busch plants. One man—not a college graduate—takes care of, changes charts and keeps in constant proper operation eighty different instruments, such as CO_2 recorders, recording pyrometers, steam-flow meters, venturi and other water-flow meters, etc., and in addition finds time to help with testing work. Where CO_2 recorders or similar instruments are not successful, it is generally due to not taking time to learn their principles of operation, and to improper installation.

Fig. 6 of my paper was not drawn to show exactly the economizer heat transmission, but rather the approximate relation between heat flow and draft loss, and represents conditions in the economizer at about 300 deg. fahr. mean temperature difference. Mr. Gibson mentions that the rate of heat transmission varies with the temperature. I wish to say that it varies rather with the mass of the gas and the velocity, both of which are, of course, dependent upon the temperature. Heat transmission in economizers with a given gas velocity will also vary, due to the influence of such factors as cleanliness of outside and inside heating surface, water velocity, and distribution of gas over the heating surface.

With Mr. Gould's opinion that I overlooked the most important point, "the character and quantity of fuel used," I do not agree, for the reason that while the quality and cost of coal are prime factors in planning efficiency methods and efficient equipment, they are not necessarily essential factors, so far as my paper is concerned. Preventable power plant losses are general over the whole country and where high as well as low-grade coal is burned, and if it pays to prevent the losses in small plants burning low-grade and at the same time cheap coal, it certainly should pay in larger plants or with higher-grade and more costly coal.

THE FLOW OF AIR AND STEAM THROUGH ORIFICES, HERBERT B. REYNOLDS

Sanford A. Moss. The author has executed some difficult experimental work in a very creditable manner. The coefficients for venturi meters at high densities are valuable pieces of contributory evidence to the general principle that an orifice or venturi coefficient is nearly unity.

The coefficient which Mr. Reynolds gives for the Taylor pitot tube is the product of the ratio of average to central velocity and of the static-hole constant of the Taylor tube, which is not unity.

Some remarks may be made regarding the formulæ used. The venturi formula given is the correct general formula both for the venturi and the plate orifice. It should never be used for computation work, however, as simplified formulæ give equal accuracy with vastly less computation.

For the case of Mr. Reynolds' venturis the differentials are exceedingly small, and the proper formula for cubic feet of standard air at 32 deg. is

$$\frac{491.5 \times 677.5\, d^2 \sqrt{[P_1 (P_1 - P_2)/T_1]}}{519.5 \times \sqrt{[1 - (A_2/A_1)^2]}}$$

For the case of the table given on Page 29, this becomes

$$286.1 \sqrt{[P_1 (P_1 - P_2)/T_1]}$$

The following table gives a comparison. There is a constant difference of a fraction of a per cent, due to difference of fundamental constants.

From table on P. 29	From above formula
8.4	8.69
10.9	11.09
13.9	14.05
17.7	17.95
21.6	21.82
25.5	25.66
29.2	29.44
33.0	33.38
38.0	38.19
42.6	42.91
46.6	46.95

The formula used by Mr. Reynolds for the thin-plate orifice is theoretically correct only for pressure ratios greater than 0.52. For less pressure ratios, the flow is dependent on the initial pressure only. I understand that Mr. Reynolds has made his computations on this basis. However, Mr. Reynolds' actual results for small pressure ratios show that the flow does vary with the final pressure. This means that the coefficient of a thin-plate orifice varies with the pressures. The exact variation is given for the first time by Mr. Reynolds and he gives a very interesting empirical law, taking account of both the theoretical and the coefficient variation and giving the net flow.

The conclusion which I think should be drawn from the data presented is that the venturi meter is much preferable to the thin-plate orifice for the following reasons:

The venturi coefficient is well established by much previous data and by Mr. Reynolds himself, as nearly unity, while the coefficient of the thin-plate orifice is variable and the net flow is a complication of this factor and the theoretical flow. Mr. Reynolds' empirical formula is very ingenious, but it would have to be established for many other cases before it would be proper to use in general.

The corner of the thin-plate orifice has an important influence and even Mr. Reynolds used two different forms,—square and with 1/16-in. radius. I believe a venturi with a well-rounded approach and some length of parallel portion can be more easily made and duplicated than a true thin-plate orifice.

Mr. Reynolds also mentions, in the steam case, an uncertainty regarding point of measurement of pressure.

He complicates the venturi case by use of the full theoretical formula, whereas much simpler and equally accurate formulæ are available. He uses a rather large venturi throat, giving small differentials which are comparatively hard to measure. One of the great advantages of the venturi is the fact that large differentials can be used by proper selection of the throat diameter.

Hence I feel that Mr. Reynolds' paper gives valuable evidence showing that the venturi meter should not be displaced by the thin-plate orifice for the case of large pressures.

MR. REYNOLDS' CLOSURE

Herbert B. Reynolds. In regard to the relative merits of the venturi tube and the thin-plate orifice for measuring compressed air and steam, I wish to say that the venturi tube considered from the theoretical point of view is a more desirable instrument. However, when the cost and other practical considerations are taken into account, the thin-plate orifice has a great many advantages over the venturi tube, as is pointed out by Mr. Pigott.

In reply to Mr. Thurston's question as to the use of venturi tubes in parallel, I have no doubt that the apparent difference of pressure noticed by him when some of the tubes are shut off is due to the pulsating pressure, as explained by Mr. Connet.

The method of measuring the air described by Mr. Connet is probably as accurate as the method used in these tests. However, I think that the gasometer method is freer from uncertainties than any other method, as it is a direct measure of the actual volume of air.

Referring to Mr. Christie's interesting remarks about the close agreement of the coefficient of the Taylor pitot tube when used in a 10-in. pipe with the coefficient which I found for a 2-in. pipe, I find that, by referring to my original curves—which are easier to interpolate—the coefficients are about 0.78 for both the 2-in. and the 1½-in. pipes.

I think that everyone will agree with me that the pinhole type of pitot tube is much to be preferred to the Taylor tube, as the coefficient of the pinhole type can be considered unity for all practical purposes if a traverse is made in the pipe or duct. The data for the Taylor tube were obtained in this case because it was desirable to calibrate this form of tube in connection with some other work.

I do not agree with Dr. Moss when he says that the formulæ which I have used should never be used for computations. One object of these experiments was to compare the actual performance with the theoretical performance, and thus I do not think that short-cut methods should be used on the theoretical side in order to save work any more than they should be used in determining the actual performance, namely, in the actual measurement of the air. A great deal of work and expense could have been saved if some simpler method had been used in measuring the air. However, the uncertainties would have been increased. On the other hand, a simpler formula might have been used in computing the theoretical flow, and giving the same degree of accuracy as pointed out by Dr. Moss, but at the same time involving uncertainties. Therefore I think in this case, with the object of the computations in view, the unquestionable correct theoretical formula should be used in comparing the theoretical flow with the actual flow.

I have made the above remarks about the approximate formula granting that it gives practically the same results as the theoretical formula. However, in investigating the formula as given by Dr. Moss, which becomes

$$Q = 286.1\sqrt{P_1(P_1 - P_2)/T_1}$$

for the 2×0.666-in. venturi tube, I find that for the lower pressure ratios it gives results which are quite far from the correct results. For example, the percentage of error varies from 0.64 per cent when the pressure ratio is 0.99892, to 34.62 per cent when the pressure ratio is 0.5821.

Dr. Moss states that the equation which I have used for the

orifice is theoretically correct only when the ratio of pressures is greater than 0.527. If used correctly this equation is theoretically correct for any ratio of pressure. However, when the ratio of pressures is less than 0.527, the value $0.527P_1$ should be substituted for P_2 in the formula. This was done whenever the ratio of pressures was less than 0.527.

Dr. Moss says that the size of the venturi throats which I have used resulted in very small differentials which are very hard to measure. Expressed in pounds per square inch, these differentials appear to be very small. However, it should be kept in mind that these pressure differences were measured in inches of water, which resulted in readings of considerable magnitude in most of the tests. In fact, in some of the tests the differentials were so large that it was necessary to use mercury in the manometer in place of water.

SPONTANEOUS IGNITION STUDIED BY MEANS OF PHOTOGRAPHIC PLATES, FREDERICK J. HOXIE

Milton F. Jones[1]. The subject of the early stages of oxidation of inflammable substances which, should the reaction continue, may terminate in spontaneous ignition, is a matter of importance regarding which very little is known.

If the author's assumption that the effect upon the photographic plate is due entirely to liberated hydrogen peroxide, is correct, then we have perhaps the first tangible evidence of the beginning of the oxidation process, in a form which would allow comparisons to be made.

That the density of the photographic image does not harmonize with the iodine number of the oil, is not remarkable. The iodine number of an oil is usually employed as a means of identification. It is based upon the capacity of the oil in question to combine with one of the halogens, that is, iodine. It is doubtful, however, whether we have the right to assume that the oil will combine with an equivalent amount of oxygen. Chlorine unites directly with some elements with which it is difficult for oxygen to unite.

Because the drying oils have as a rule the higher iodine numbers, and are prone to spontaneous ignitionn, it has been suggested that the iodine number might prove a guide in determining the tendency of an oil in this direction. Boiled linseed oil possesses greater drying properties than raw oil, and is usually considered more hazardous, yet it seems to have been conclusively demonstrated that it has the lower iodine number. The ordinary red oil which is a crude oleic acid obtained from tallow, an animal oil, is probably as hazardous as regards spontaneous ignition as linseed oil. Cottonseed oil is not considered a drying oil.

The statement of the author that all charcoal is not alike will hardly be questioned; it is one of the most perplexing factors in the investigation of charcoal fires. He finds that the density of the photographic image corresponds with the activity of the sample of charcoal, which is interesting. The conditions as to charcoal are different from those of oil. In the latter case, having determined that an oil is hazardous, it can be safeguarded more or less. With the charcoal, however, although many samples may show an inactive condition, one active piece favorably located in a pile may under certain conditions determine the destruction of the mass.

As the author states, the results are only a beginning, and subsequent research will determine the value of the process, whether of scientific interest only, or whether applicable to industrial or fire-prevention uses.

[1] National Fire Protection Association, Boston, Mass.

STANDARDIZATION OF MACHINE TOOLS, CARL G. BARTH

Fred A. Parsons. Regarding standardized progressions for speeds and feeds and standardized power, the paper presents what is without doubt the ideal condition, but in application the following points should be borne in mind:

1 At present a very small percentage of machine tools goes to factories where the management would appreciate the refinements in feed and speed ratios suggested. Indeed, the jobbing shop could never get together with the manufacturing plant on the question, since the former requires a wide range of speeds with large ratios and the latter a small range of speeds and feeds with small ratios.

2 Present machine-tool feeds and speeds are very largely the outgrowth of the above conditions, though there are no doubt many instances, as the author mentions, where no particular attention has been paid to anything except getting the high and low speeds required.

3 Present milling practice seems to require of general-purpose machines, such as the plain knee-and-column type, about the same number of feeds as of speeds, but a total ratio of about 24 to 1 for the speeds as against about 48 to 1 for the feeds. Unless present practice is wrong, this would require two different progression ratios.

4 Some designs permit considerable economies to be effected in space and parts required by attempting only a fairly close approximation of the perfect geometrical progression. An instance may be considered of obtaining nine speed variations with nine gears on three shafts, the gears on first and last shafts being sliding gears and on the intermediate being laterally stationary. In this case it is not possible to reach any perfect geometrical progression exactly, if the high and low speeds are even fairly far apart, but a close approximation can be obtained.

5 Considering that by practically any method of drive the variation from normal speed at no load and at full load will be up to 5 per cent, is it warrantable to add cost to a machine tool to come closer than a few per cent above or below a given geometrical progression?

6 Mr. Barth has stated in his paper, that the standardization of speed ratios should be accompanied by a standardization of power for machines of a given type and size. Such a standardization must be considered from the standpoint of the user. At present the users seem to demand two power capacities of any given range, one light and one heavy, and it is hard to see how this could be avoided, as otherwise some will be purchasing power capacity they do not need, though they require the range, and in the other extreme the reverse would be true.

7 It seems unquestionable that a few years more will see the development and general application of a machine-tool drive for both feed and speed in which the speed variations can be represented by a smooth curve from minimum to maximum. Such a drive is typified at the present time by the variable-speed motor; the objections are that it is expensive to install and cumbersome. Such a drive will not of course apply to lathe feeds for screw cutting, or milling-machine feeds for spirals.

Regarding the standardization of details such as T-slots, taper shanks, etc., which Mr. Barth mentions, there are not the difficulties which enter into standardization of speeds and power. The cases are quite different, inasmuch as if a T-bolt, for instance ¾ in. in diameter, is being used in an appropriate place, there must certainly be only one correct depth

of slot, considering strength for any given material, the same as there is one best size for the square and thickness of bolt head.

H. M. Norris. That some machine-tool builders are learning to appreciate the value of a smaller speed variation is attested by the fact that fifteen years ago no radial drill was provided with more than eight changes, while now they may be obtained with 20, 24 and 30. The speeds of most of these later tools are intended to be in geometrical progression, but I am of the opinion that a geometrical series is not the best for a drilling machine.

The ratio of progression most favored by Mr. Barth appears in the first column of Table 1. The second column gives the corresponding number of revolutions per minute, and the third the diameters of drills which this series would drive at a cutting speed of 80 feet per minute. To my mind this is not as efficacious a series as that obtained from a ratio giving both desired extremes, columns 4, 5 and 6. Here we have fifteen speeds for drills from ⅝ to 4½ inches in diameter, while under the former gradation there are but twelve.

But why use either? Instead of deciding upon a series and then seeing what drills it will drive at a certain cutting speed, is it not better to decide first upon the drill diameters and then try to obtain the exact speed for each, regardless of the ratio of advance? Suppose, for example, we set down, as in column 7, the diameters of drills we would like a machine to drive at a cutting speed of 80 feet per minute. It is an easy matter to ascertain at what number of revolutions per minute each should run, column 8. Here each *harmonic* group of speeds may be obtained from a five-change speed box or a 2-to-1 motor, while back gears made in the ratio of 1 to 1, 1 to 2, 1 to 4, 1 to 8, etc., will give as many successive *geometric* groups as desired.

Mr. Barth states in his paper that "It is by this time universally accepted by those who have a right to an opinion in this matter that the available speeds of a machine should be in a geometrical progression," and that "a discussion of this will not be undertaken by him unless provoked by some one else." It is not my purpose to provoke an argument, but I would like to learn if I am in error in thinking that my series is the best of the three.

TABLE 1 COMPARISON OF BARTH, NORRIS, AND USUAL METHODS OF CALCULATING DRILL RATIOS

Barth			Usual Method			Norris		
Ratio	R.P.M.	Diam. In.	Ratio	R.P.M.	Diam. In.	Diam. In.	R.P.M.	Ratio
1.000	43.3	7.09	1.000	67.9	4.50	4½	67.9	1.000
1.189	51.5	5.93	1.152	78.2	3.91	4	76.4	1 125
1.414	61.2	4.99	1.326	90.1	3.39	3½	87.4	1.285
1.682	72.8	4.20	1.527	103.7	2.94	3	101.9	1.500
2.000	86.6	3.53	1.759	119.4	2.56	2½	122.2	1.800
2.378	102.8	2.97	2.025	137.5	2.22	2¼	135.8	2.000
2.828	122.3	2.49	2.332	158.3	1.93	2	152.8	2.250
3.364	145.6	2.10	2.686	182.2	1.68	1¾	174.5	2.570
4.000	173.2	1.77	3.093	210.0	1.46	1½	203.8	3.000
4.757	205.8	1.48	3.552	241.0	1.27	1¼	244.4	3.600
5.657	244.8	1.25	4.103	278.6	1.098	1⅛	271.6	4.000
6.727	291.0	1.05	4.725	321.0	0.952	1	305.6	4.500
8.000	346.0	0.883	5.441	369.0	0.838	⅞	349.2	5.140
9.514	411.6	0.742	6.266	425.0	0.720	¾	407.5	6.000
11.314	488.9	0.625	7.215	488.9	0.625	⅝	488.9	7.200

MR. BARTH'S CLOSURE

Carl G. Barth. While I am rather disappointed at the fewness of the discussions of my paper, the, on the whole, very favorable discussion by an engineer who has given so much independent attention to the subject as Mr. De Leeuw, is compensation enough for my having taken the trouble to prepare it. Regarding Mr. De Leeuw's comment that certain machines, as, for instance, large boring mills, would be better provided with two *bunches* of speeds, I agree with him fully; but will insist that each bunch should conform to the principles advocated by me. I also agree with him that more experiments with cutting tools should be made, and am pleased to inform him that more is known about the art of cutting metals with planer tools, milling cutters and drills than has as yet been published. For fully ten years I have thus had a set of slide rules covering certain milling cutters on the one hand, and gear cutters on the other hand, which have been of substantial assistance to me in my efforts to improve shop practices; and if I live long enough, I shall fully disclose their theory, construction, and application, together with much else relating to the art of cutting metals. Regarding Mr. Norris' discussion, it discloses such a fundamental lack of grasp of the whole matter considered, that I would be inclined not to waste any words upon it, beyond stating that it proves that he belongs to the other class I had in mind when I referred to "those who have a right to an opinion in this matter." However, being a great admirer of the many excellent features of the line of radial drill presses he has developed during a term of years, I am glad to point out that his mistake consists in neglecting to take account of the fact that the proper cutting speed of a drill—just as much as of a lathe tool and a milling cutter, etc.—varies with the diameter of the drill, the feed used, and the hardness of the material drilled; and that there is an exceedingly small increment between all the drills used in nearly every shop. Hence, theoretically, to meet every combination of these variables between a maximum and a minimum, infinitesimal increments would be required, in the absence of the possibility of obtaining which, *equal-percentage* increments become our only rational practical approximation; and that is, in a nutshell, all the reason and argument there is behind a geometrical progression of speeds, and it is all that is needed. Regarding Mr. Parsons' discussion, I fully agree with him that at present but a small percentage of machine tools goes to the factories where the management would appreciate the refinements of the feed and speed ratios suggested by me. However, it has been my business for a number of years to help managements to such appreciation, and I think the machine-tool builders should again help *me* do it. The field I can personally cover is exceedingly limited, whereas, theirs is unlimited. What he says about the relation of feeds and speeds of general-purpose milling machines is not clear to me, so I cannot comment upon it. I never expected all attempts at a geometrical progression of speeds to turn out even a practical perfection, but, I have fully demonstrated in my paper that there is no inherent difficulty in doing better in numerous instances than what has been done. I have said nothing in my paper that excludes any number of sub-standards of machine tools, as regards power. Thus, I fully believe that there might to advantage be both a heavy and a light standard of any work capacity (as opposed to chip-producing capacity) of several of the more common types of machine tools. For reasons that I prefer not to reduce to writing at the present time, while much misunderstanding still exists regarding my work as a scientific-management expert, I do not favor any kind

of continuous speed or feed variator for the mere sake of getting the closest possible speed adjustment (which nobody can hope to know closer than a rather uncertain percentage anyway, for any set of practical conditions), though under certain conditions I strongly advocate adjustable-speed motor drives, because of the quickness with which they enable speed changes to be effected.

ACCURATE APPRAISALS BY SHORT METHODS, J. G. MORSE

CHAS. W. MCKAY[1]. The reproduction cost of the property, tangible and intangible, the present or depreciated value of the property, the cost of producing and marketing the plant output, and the capacity of the plant, are all factors which should be carefully considered in attempting to evaluate an industrial property. Of these elements reproduction cost and present value, if not the most important, are at least worthy of careful consideration, and in the following paragraphs is briefly outlined a method of manufacturing-plant appraisement patterned after current practice in public-utility valuation work. The grand summary of such an appraisal would take somewhat the following form:

GRAND SUMMARY OF MANUFACTURING-PLANT APPRAISAL

	Reproduction Cost.	Present Value.
Direct Construction Costs:		
Land	....	(Same)
Buildings	....	....
Machine Tools (lathes, boring mills, etc.)	....	....
Auxiliary Equipment (chucks, etc.)	....	....
Electrical Equipment (motors, rheostats, etc.)	....	....
Belting	....	....
Shafting	....	....
Small Tools and Dies	....	....
Patterns and Drawings	....	....
Stock and Supplies	....	(Same)
Furniture and Fixtures	....	....
Total Inventoriable Property	....	....
Omissions and Contingencies	....	....
Purchasing Expense During Construction	....	....
Tools and Tool Expense During Construction	....	....
TOTAL DIRECT CONSTRUCTION COSTS	....	....
Collateral Construction Costs:		
General and Legal Expense During Construction	....	....
Engineering and General Supervision During Construction	....	....
Taxes and Insurance During Construction	....	....
Interest on Investment During Construction	....	....
TOTAL COLLATERAL CONSTRUCTION COSTS	....	....
Non-Physical (or Intangible) Assets:		
Value of Patent Rights	....	....
Value of Trade Marks	....	(Same)
Value of Going Concern	....	(Same)
Value of Goodwill	....	(Same)
TOTAL NON-PHYSICAL ASSETS	....	....
GRAND TOTAL	....	....

Inventoriable Property. As to the inventory and appraisement of the strictly physical property, an appraisal made by a consulting engineer should be equally well adapted to serve for tax adjustment, insurance or accounting purposes or as a basis for the determination of fair value in the event of the sale or reorganization of the property under consideration. The inventory should be accurate, within reason, and should be based upon sound engineering and economic principles, so that it can successfully withstand the scrutiny to which it is almost certain to be subjected if presented before the courts.

Mr. Morse's plan is a little too broad to meet the requirements just outlined. He is merely satisfying his clients, or his employers, as to the physical value of the risks they are undertaking. They have sufficient confidence in him to warrant their acceptance of such short-cut methods as he may see fit to employ, knowing full well that he will be able to substantiate his valuation in the event of a call for claim adjustments. Nevertheless, it is very probable that the Factory Mutual Companies, or any other insurance organization, would be somewhat loth to accept valuations made by outside engineers based upon these rather broad-gage methods. In any event, it is probable that an engineer in submitting such an appraisal would experience considerable difficulty in "getting by" with the courts, in the event of a lawsuit over the value of a manufacturing property, or in using it as a basis for capitalization.

In a manufacturing-plant appraisement, the inventory should be made in sufficient detail to facilitate its ready analysis by opposing experts, in the event of legal action, and should be so arranged as to render the various elements of plant segregable for accounting or insurance purposes.

The attitude of the courts has been unfavorable toward real-estate appraisements made by consulting engineers, and, to be on the safe side, it is usually best in the long run to have land appraised by a real-estate broker of unquestionable standing and the buildings preferably by the architect under whose supervision they were erected. The auxiliary building equipment, however, such as elevators, piping and wiring, should, so far as possible, be considered as a part of the building rather than as a part of the machine equipment, as suggested by the author. Of course, exceptions may have to be made, as in the case of special wiring for motor-driven machinery.

As to the preparation of the unit costs of the inventoriable property, it is better for all purposes, with the possible exception of insurance appraisals, to carefully investigate them for a period of a year or two preceding the appraisal, and if those prevalent at the appraisal date seem to be abnormal, to use average prices.

Omissions and Contingencies. No matter how carefully an inventory may be made, there is always the probability that items, perhaps individually of small value, but which when taken collectively may amount to an appreciable sum, will be entirely omitted. In public-utility work, the usual allowance to compensate for such omissions, and one which has had the sanction of the courts, is two per cent of the reproduction cost of the inventoriable property.

The word "contingencies" as used in appraisal work may be defined as the monetary allowance which may be added to the appraisal of the inventoriable property to compensate for such unforeseeable contingencies as may arise in the construction of the property and which cannot be taken account of in the preparation of the unit costs. In public-utility appraisal practice it is usual to add an allowance of about two per cent of the reproduction cost of the inventoriable property. Similar conditions are encountered in manufacturing-plant appraisal work, and there is no reason why a specific allowance should not be made for omissions and contingencies.

Purchasing Expense During Construction is a very appreciable item, involving, as it does, the securing of competitive bids and possibly visits to the manufacturers' plants to inspect machinery. This may be cared for on a percentage basis, the allowance depending largely upon the nature of the equipment involved.

Tools and Tool Expense During Construction. This item includes not only the original cost of the tools, but also the cost of maintaining them during the construction period. In public-utility work, an allowance of 2 per cent of the repro-

[1] McMeen & Miller, 1454 Monadnock Block, Chicago, Ill.

duction cost of the inventoriable property is not unusual for this item.

General and Legal Expense During Construction. This item includes the general expense of the executive organization during the construction period, the cost of temporary offices for the bookkeepers, timekeepers, paymasters, etc., and the cost of legal counsel for incorporating the company. In manufacturing-plant-appraisal work a suitable allowance for this item, based on the reproduction cost of the inventoriable property and depending upon the nature of the property involved, will probably not exceed two per cent.

Engineering and General Supervision During Construction. Plans have to be prepared for the general layout of the buildings and transportation facilities, as well as for the distribution of the machinery in the buildings themselves, and in many plants it is customary to retain an engineer throughout the entire construction period to supervise the erection of the plant and the installation of the equipment. The usual allowance for this item varies from 5 to 9 per cent of the reproduction cost, depending upon the nature of the property involved.

Taxes and Insurance During Construction are unquestionably capital expenses, and should be included in the determination of the total reproduction cost of a manufacturing property. An adequate estimate may be made by ascertaining the insurance and tax rates prevalent at the time of the appraisal.

Interest During Construction. Up to the time the plant starts production, this item is just as real a part of the total investment in the property as is the cost of the inventoriable plant. For all practical purposes, interest may be computed with sufficient accuracy by ascertaining the interest rate prevalent at the date of appraisal and applying one-half of this rate to the total physical costs, including General and Engineering Expense, Taxes and Insurance.

Intangible Assets, or, more properly, non-physical assets, include Value of Patent Rights, Going Value, Value of Trade Marks and Goodwill, and constitute the major portion of the total value of an industrial property. The method of determining their value is so dependent upon the exigencies of individual cases that it is useless to attempt to outline a general plan for their determination.

Depreciated or Present Value of the inventoriable portion of the plant. This may be determined along the lines suggested by Mr. Morse. The items Omissions and Contingencies, Purchasing Expense, Tools and Tool Expense During Construction, and all of the Collateral Costs, should be depreciated at the same rate as the inventoriable property, i. e., the present value of the inventoriable property divided by its reproduction cost will give a condition per cent which may be applied to the reproduction cost of the items Omissions and Contingencies, Purchasing Expense, etc., to obtain their respective present values.

It is undoubtedly true that some of the appraisals prepared by the so-called appraisal companies contain needless detail, and, furthermore, that the accuracy of inventory is ofttimes more than offset by erroneous assumptions as to depreciation and by too close adherence to standard unit costs. This raises the point that the problems involved in manufacturing-plant-appraisement work are strictly engineering problems, requiring the experience and judgment of trained engineers.

The short-cut methods prescribed by the author, on the other hand, while admirably adapted for his own purposes, are, it would seem, a little too approximate in their nature to warrant their general adoption for engineering valuations. Is it not true that there is a happy medium between these two plans, and that this medium can be best reached by observing, and to a certain extent copying, the methods adopted in the public-utility appraisement field?

Then again, when preparing a reproduction-cost appraisal, why appraise the inventoriable property with great care and accuracy and then omit entirely elements which are just as inevitably a part of the cost of reproducing a property as the cost of the machinery or tools? It is true that the collateral and intangible elements may not be necessary for some of the uses to which manufacturing appraisements are put, but, on the other hand, they are most essential for the determination of fair value in the event of sale or reorganization of properties.

PRODUCTIVE CAPACITY A MEASURE OF VALUE OF AN INDUSTRIAL PROPERTY, H. L. GANTT

R. S. Hale. Many of the questions about cost and value would become simpler if we would give up the idea that there is any abstract "cost" or "value," and instead should work on the basis that the business of the accountant and engineer is to provide data which will make it easier for the executive to answer certain questions, or rather to enable the executive to take action.

The first of the two theories of costs given by Mr. Gantt, by which all the expenses are included in the cost, gives a figure that helps the executive decide whether he can afford to declare a dividend, but is not of very much use for deciding what the expenses will be next year.

The second theory, by which only the expenses actually needed for the production of an article are charged to its cost, gives a figure which is useful in determining what the expenses may be next year, but is not particularly useful in deciding what profit the concern has made the past year.

There is no such thing as an abstract "cost," or if there is it is of no use to any one. Sometimes we want to know whether we have made or lost money during a given period. In other cases we want to know how much our expenses will be increased if we put some by-product on the market. In that case we want to know *only* the real extra cost of the by-product. In still other cases a factory owner may want to know whether he had better shut down his factory for a period, or run it until the market for the product improves. To answer this question he needs an entirely different set of figures than when he is deciding whether or no to build a new factory.

Mr. Gantt's charts are exceedingly valuable, because they help the executive to decide what he could have done if he had had more material, or if he had had more orders, or had had more help. Likewise they help show what could be done if certain idle machinery were disposed of, etc. The cost figures they show are, however, more than useless in some cases; but the same is true of all cost figures.

Practically every theory of cost or theory of valuation helps to answer some particular question, and it is only a matter of logic to say that we shall continue to have new cost theories and new value theories so long as new questions are coming up to be answered.

The point it is desired to emphasize is that abstract "cost" and abstract "value" are of slight or no importance. What the accountant and engineer should give the executive are the figures that will help solve the *particular* questions that are asked in a particular case, and they should not put these figures in any form that would cause them to be used improperly, nor should they give them any abstract name that

would have the same result of misleading the user of the figures.

A. C. Jewett. The expense of idle equipment shown by Mr. Gantt's chart must be combated, so far as idleness due to lack of orders is concerned, by an intense study of the sales problem. The engineer must direct the sales policies. He must direct the distribution of the products of industry. The consuming power of mankind is not limited. It is the distributing mechanism that is at fault when machinery in the mills and factories is idle and many people lack sufficient food and clothing. When the problem of the proper distribution of the products of industry is solved there need be no idle labor, the cost of living will not be an acute problem, and there need be no complaint about the length of the working day.

This is not new, but it is new for the engineer to give serious attention to matters such as these as a part of his work of industrial management. The solution of these problems and all that they involve is not an easy task, but it is one that no engineer can afford to neglect and that all ought to study earnestly.

J. B. Milliken.[1] To make our position clear, we define the valuation of industrial property to mean the value at which the physical manufacturing property of a corporation is carried on its books. We mention this because Mr. Gantt's paper evidently contemplates a different definition, viz., one including the efficiency of the plant, which involves the value of the organization operating it, which latter he states "is an integral factor in the valuation of an industrial property." We agree with Mr. Gantt, if by industrial property he means all the values which are represented by the capital stock of a corporation, in which case the value of the management is reflected in the profit and loss account and in the market value of the corporation's shares; but the value of an organization cannot properly be reflected in the physical assets of the corporation as shown by its books.

Our view is that the valuation of land, buildings and equipment should be shown on the books of a corporation at their original cost, less a depreciation for use or obsolescence. As a check on our valuations and on our depreciation ratios, we have appraisals made by professional appraisers at intervals of approximately ten years and compare results carefully with our valuations.

In contrast with the *accounting method,* which should be based on actual cost, we believe that *appraisals* should be made on the basis of present cost to replace, less proper allowance for age or for obsolescence, rather than on the basis of original cost, as the latter may be difficult to determine at the time of the appraisal and in some cases may represent more or less than real value, even at the time of purchase. A careful appraisal may disclose excessive original costs, for example, in which case a question arises as to whether the valuation of a given item should be reduced to agree approximately with the appraisal. Great care should be exercised in comparing appraisal values made on the basis of replacement values to avoid taking advantage of an abnormal present cost, such, for instance, as would occur in the case of appraisals made at the present time, due to the very high prices of practically all materials and labor.

We believe that actual cost, whether higher or lower than normal, should be the basis of all values on a corporation's books. It is conceivable that two factories might be exact duplicates and yet show original cost of construction and equipment widely variant. The proper course in such a case is not for the higher-cost company to reduce its valuation, which was its actual cost, but to justify its cost through its profit-and-loss account by increased earnings, if it can do so, so that a comparison of its ratio of net earnings to capital invested in plant may compare favorably with that of its competitor. This method discloses the facts, both of the actual cost of the property and the actual earnings, whereas reducing the cost on the books by a charge against earnings (in excess of reasonable annual depreciation) distorts the facts as to both earnings and assets.

[1] Treasurer, The Yale & Towne Mfg. Co., Stamford, Conn.

J. H. Williams.[1] Mr. Gantt recommends the use of "constant" cost rates in cost accounting as a means of increasing efficiency of production. The writer would go further and recommend the use of *standard* as well as "constant" cost rates.

By cost *rates* is meant the *percentage* to be added to direct wage and the hour *rates* for the different machines; by *standard* cost rates, rates representing what the cost *should be* as distinguished from what *it is.* The determining of *standard* cost rates is to the same end as time study and the determining of standard methods and time.

Overhead costs and volume of work which are the only factors affecting cost *rates* as here defined are not subject to the same kind of study as operations, but they are equally susceptible of scientific study.

The use of standard cost rates makes possible a daily comparison of the aggregate of the amount charged on the cost records (at standard rates) with the aggregate of the actual cost. Any difference is shown in dollars and cents in the aggregate instead of in the rate. The occasion of the difference, if any, is ascertainable through subdivision of the actual cost into the items used in determining the standard rates.

Through the use of standard rates we are able, as above explained, to determine our profit or loss due to *volume* daily; and by analysis of actual cost and comparison with standard cost, to determine their source.

On the other hand, through using the same *standard rates* in keeping production-cost records, we are also able to determine our profit or loss due to *efficiency* daily by jobs as they are completed. By comparing the actual with the estimated cost of production we are able to determine the operations in which the profit or loss occurred.

In this wise we have a daily statement not only of profit and loss but also a statement as to the several exact sources of profit and loss, and one wherein the difference between the aggregate daily profits and aggregate daily losses will agree with the increase and decrease in assets and liabilities, as shown in the monthly, quarterly, or yearly closing. In no other way can profits and losses be accurately determined daily, or in such a vast number of items. The timeliness and detail of these statements is of the utmost importance in their effectiveness.

R. B. Shepard, Jr.[2] I am particularly impressed with the paper by Mr. Gantt and heartily subscribe to his dictum that the productive capacity is a measure of the value of an industrial property. Indeed, I will go even farther and assert that productive capacity, taken in conjunction with the desir-

[1] 772 Park Avenue, New York, N. Y.

[2] Office Engineer, Atlantic Coast Line R. R. Co., Wilmington, N. C.

ability of the product from the consumers' point of view, in other words the *earning capacity,* is *the* measure of value, and the only measure unless natural economic conditions have been artificially disturbed. It is remarkably significant that most of the valuations heretofore made have had as their object not the determination of absolute value, but rather the ascertainment of a limit below which public bodies could not arbitrarily depress value through interference with charges for the commodities produced. Granted the power of the public to regulate charges for service rendered by so-called public utilities, subject only to constitutional restraint against confiscation, the only unassailable position open to public utilities in the protection of their interests seems to be that confiscation results when earnings are so reduced by arbitrary action of regulating agencies that fair returns on the capital employed are denied, and the cost of reproduction seems to afford the readiest measure of the sum of capital, or capital equivalent, engaged in the service; hence the disproportionate importance to which the estimated cost of reproduction seems to have attained in current schemes of valuation. To the owner the cost of reproduction does not signify value but is definitely related to the cost of the output of his plant. For his business to be profitable, it must yield a sum sufficient to meet all costs of operation and leave a balance from which to pay interest on the confined capital and a profit. The value is commensurate with the size of this balance, not with cost, or capital equivalent.

The term "cost of reproduction" should, in the writer's opinion, be interpreted to mean the total investment which would be required to replace the object under consideration, including working capital, development costs, etc., etc.; that is, the absolute sacrifice, expressed in terms of money, which would be required for present production, in its entirety, of the completed and operating utility. This is a somewhat more comprehensive definition than is generally attached to the term, but it is justified by the economic functions of the estimated cost of replacement.

For the ascertainment of absolute value recourse must be had to the balance sheet, the past history and the future prospects of the business. The balance sheet does not disclose the value in stated terms, but it furnishes the data as to results of operation and the present financial condition of the business on which the calculation of value must be founded. The value has no fixed relation to the investment. It is, of course, affected by the judgment used in making the investment, the efficiency of the organization, the confidence of the purchasing public, the general condition of prosperity and enlightenment of the community, etc., but these are matters more for the consideration and activity of the managers than of the appraisers, especially as their practical effects are reflected in the balance sheet and enter, along with all other influential facts, into calculations based on data taken therefrom. No definite conclusion as to value could be drawn from the study of operations for one or two years, but the examinations should extend over at least a decade in order that periods both of depression and of prosperity could influence the findings.

This method of valuation is applicable to those industries only which are more or less free to respond to economic influences. For others, subject to regulation and price fixing by external agencies, purely arbitrary methods must be evolved if the valuations are to enter into the contest or construction of rates of charge. To meet such a situation, the industries must claim the right to profitable operation and contend that profitability ceases when the earnings are not sufficient to pay all costs, including interest at reasonable commercial rates on total capital equivalent and, in addition, yield a profit in proportion to the size of the business handled. This is the rock bottom of permissible depression. The criterion should, in equity, be the relative extent to which the regulated, as compared with unregulated, industries are permitted to participate in the general prosperity and welfare.

F. J. COLE. Mr. Gantt does not state whether the items in his idleness expense chart are a copy from an actual day's run at some mill or typical. It is significant, however, that out of \$1969 total cost of idleness, \$1630, or 83 per cent, is chargeable to lack of material or to poor material.

One of the principal sources of expense in the production of any manufactured article is the loss due to an insufficient supply of material, either in not having it at the machines when needed in sufficient quantities, or it being of improper quality.

Where many kinds of materials are used and their quality is more difficult and complex, more systematic work is required in the purchasing, inspection, tracing and delivery of such materials in order to avoid serious delays.

Proper scheduling of events or processes in the making of manufactured articles is most necessary in order to determine the correct anticipation of dates when things must be *done.* This scheduling includes the dates for ordering and delivering of material, inspection, tracing shipments and manufacturing operations of various parts and processes so that the doing of the necessary events is maintained in their proper sequence.

Using all the machines all the time is most economical, but whether it can be done always depends upon many conditions. A surplus of machines is sometimes required to take care of variations in product, where the character of the work varies considerably with different articles of the same general class which are being manufactured.

A daily statement of the losses in dollars and cents incurred through idle machines, idle processes, caused by the percentage of time they are idle, must be a great object lesson to a management in calling prompt attention to the monetary loss caused by idleness in operating below maximum capacity. The idleness expense chart proposed by the author shows at a glance the loss in values, in percentages of idleness, and their cause.

A GAS PRODUCER FOR BITUMINOUS FUEL, O. C. BERRY

GODFREY M. S. TAIT. The methods used by the author for the determination of the tar content are all highly practical as applied to the experimental apparatus used, but would, of course, have to be modified in connection with a test of a plant in regular service.

The author's theory as to the volume of recirculated gas is not original, having been tried with more or less success in Europe, the main difficulty experienced being the power consumed by the blower and the excessive quantity of steam thus introduced—unless some arrangement were provided for connecting the governor on the gas engine to the by-pass blower so as to control same. With low load and the by-pass blower running full capacity, it was possible to lower the temperature of the fuel bed to such a point as to shut down the engine, hence the need of some form of automatic control.

Also the findings, as to clinkers, are apt to be misleading, due to the very small size of the producer in question.

The ideal conditions of draft current in a gas producer consist of a perfectly balanced draft at all loads. Any arrangement to get away from this balanced condition greatly

increases the tendency to clinker in all kinds of fuels, for be it understood that the clinker is first formed by a fissure forming in the fuel bed, and by the concentration of draft through such a channel, with a blowpipe effect that fuses the ash and fuel, and that the only way to prevent clinkers is to so arrange the fuel bed that the tendency to form such fissures or "pipes" is reduced to a minimum. This is best accomplished by using fuel beds of generous dimensions and grates that insure equal distribution of the draft current to all parts of the fuel bed at all loads.

In practice it will be found that the resultant increase in efficiency due to the fixation of the tarry vapors of the gas, rather than to wash them out and waste them, is much less than would be expected. If such figures have been worked out by Mr. Berry, the results would be of interest.

Personally I rather lean to the construction of bituminous producers along the line of simple single-zone up-draft, with attached tar washers, as being more adapted to the hard usage of practice, and have in mind a single 400-hp. up-draft, balanced-draft producer, operating on Illinois slack, costing 85 cents a ton delivered, said coal having 4 per cent sulphur content, 22 per cent ash, and 38 per cent volatile matter (10,300 B.t.u.). This producer was installed without any spare unit to help out, and has operated 24 hours per day since August, 1910, using $1\frac{1}{4}$ lb. of coal per hp-hour. I mention this plant as a case in point on the clinker question, as this fuel had a bad reputation in that respect (as well as others).

Also as to the reduction of CO_2 to $2CO$, my own experience indicates that perfect reduction occurs at 1800 deg. fahr., provided that the draft velocity is sufficiently low to allow the time necessary for the reaction. The faster the flow of draft through the fuel bed, the higher must the temperature be for this reason.

Mr. Berry should continue his investigation under conditions entailing more commercial conditions, variable load, without special attention, and noting the possibility of keeping the gas tar-free during such variations without undue attention and the effect of large grate areas; for example, in producers 10 ft. inside diameter, for all producer builders have had the sad experience of discovering that the design that was most successful at 36 in. diameter was far from such on twice that diameter, etc.

C. M. GARLAND. The studies recorded in Mr. Berry's paper are very interesting and the methods of investigation, together with the design of the producer, are both novel and ingenious. There are several points brought up in the paper, however, which the writer feels have not been sufficiently described and on which further information would be very desirable.

Regarding the removal of ash and clinker from the producer: from the drawing it would seem that the burner for the recirculating gas takes up a large portion of the grate area. It would also seem that this burner would be in danger of clogging through an accumulation of ash. Regarding the formation of clinker: the combustion of the recirculating gases, while it would undoubtedly destroy the tar, would, however, produce a high temperature in the ash zone which would greatly facilitate the formation of clinker, even with fuels which would not clinker in the ordinary producer. Due to the recirculating of the gases and the high temperature, which are apparently maintained even in the coking chamber of the producer, the clinker formation might begin very high in the producer. In this connection temperatures through the fuel bed and of the gases leaving the producer would be very interesting. The removal of the gases from the side of the producer is another element that would tend to cause the formation of clinker, particularly around the side walls.

Data on the calorific value and the composition of the gas from the producer would also be very desirable. The design would unquestionably eliminate tar and produce a gas of low calorific value. While the gas of low calorific value, in so far as power is concerned, is not objectionable, the power end of gas-producer work today is a comparatively small end of the work and is more than likely to decrease rather than increase.

The ideal to be approached in the elimination of tar is a producer in which the tarry products are converted into fixed hydrocarbon gases which would raise the calorific value of the gas instead of lowering it. The demand today is for a producer gas to replace fuel oil. This gas must have a high calorific value in order that high furnace temperatures may be produced.

MR. BERRY'S CLOSURE

O. C. BERRY. Mr. Tait calls attention to the methods used in testing for tar. It is very important to know that the gas leaving this producer is entirely free from tar at all times. The method used in making this test is a very searching one and can be applied continuously and without difficulty in any power plant where either live steam or compressed air is available. It consists in maintaining a vacuum of about 20 in. of water inside of a large glass bottle by means of a steam or an aspirator. The bottle should have a wide mouth closed by a stopper. To this stopper is attached the support for a slip of white cardboard. The gas to be tested for tar is led into the bottle through a glass tube. This tube is drawn down to a small opening at its lower end and bent so as to cause the gas to impinge against the paper at right angles and at a high velocity. The presence of the slightest trace of tar in the gas will cause a brown spot to form on the cardboard immediately. This method is very easy to apply, and has the advantage of being very searching and at the same time very quick to react.

I feel that if Mr. Tait will make a closer study of the European producers he will find that they have not been worked out along the lines here presented, though some of them have been very similar. In some cases I have had a hard time to see for myself why the older producer should fail and my own be worthy of success. There has been a reason in each case, however, even though the search for it has caused some anxiety on my part in the early stages.

The work of O. Boudouard, published in the Comptes Rendus de l'Académie des Sciences in 1899 and 1900, has been widely referred to. It would seem to indicate that a temperature of 1800 deg. fahr. is sufficient to decompose the CO_2. The element of time has been left out in this work, however, as is shown by the later work done by J. K. Clement, L. H. Adams, and C. N. Haskins for the Department of the Interior, U. S. Bureau of Mines, and published in their Bulletin 7. Here it is shown that at a temperature of 1832 deg. fahr. the gas must be in contact with coke for 123.2 sec. in order to decompose 78.4 per cent of the CO_2. This is entirely prohibitive, as Mr. Tait will see.

I am sorry to be unable to present a detailed sketch showing Mr. Garland just how the gas burner avoids clogging up with ash. The removal of the ash and clinker is as easy to accomplish in this plant as it is in the standard anthracite plant, and the burner is so designed as to avoid any possibility of clogging up, and never has to be cleaned.

The burning of the recirculated gas tends to lower rather than raise the temperatures met with in the combustion zone of the producer, and has never been the cause of the formation of clinkers. The formation of clinker in the coking zones of the producer is unthinkable, as the temperatures there are below 1200 deg. fahr., while it is a poor coal having an ash with a fusing temperature as low as 2350 deg. fahr., while good coals will not clinker below 2750 deg. fahr.

The heat value of the gas from this plant seems to vary between 125 and 150 B.t.u. per cu. ft., the same as anthracite gas. The high heat values reported in connection with producer gas from bituminous fuel are due quite largely to the presence of tar vapors in this gas, and would be impossible without these vapors. Such a gas is ideal for some types of furnace work, but cannot be used in an engine.

Mr. Rathbun takes exception to the cleanliness of this gas. He knows that the gas from an anthracite plant is the cleanest gas that can be gotten from any type of gas producer, and is also the easiest to separate from what little dirt it does contain. The gas as it leaves this producer is in a class with anthracite gas. It is not clean enough to use in an engine in the condition in which it leaves the producer, but it is the easiest gas to clean that there is.

Mr. Smith is correct in his statement that it will take considerable fixed carbon in the coal to reduce all of the CO_2 and H_2O formed by the combustion of a large amount of volatile matter. It is probable that not all of these gases are completely burned. The tars can be completely destroyed by passing them through an incandescent zone, and some of them are probably eliminated in this way. As a matter of fact, nearly all of the tests on this producer have been made with Indiana and Illinois coals, having about 8 per cent moisture, 35 per cent volatile matter, 49 per cent fixed carbon, and 8 per cent ash. No trouble was experienced in keeping a sufficient bed of coke with any of these fuels.

Whether Mr. Chapman's objection on the score of a deep fuel bed would hold in the case of a larger plant, is problematical. In the case of the plant here shown it is 4 ft. deep, which is not too deep to poke with ease.

Reliability in a producer of this character cannot be established by a series of laboratory tests. It requires years of use in many power plants. I hope that the future may establish the predictions which the laboratory tests have lead us to make for the future of this type of producer.

THE RATIO OF THE SPECIFIC HEATS AND THE COEFFICIENT OF VISCOSITY OF NATURAL GAS FROM TYPICAL FIELDS, ROBERT F. EARHART

H. B. BERNARD. Due to the many features encountered in piping natural gas, such as condition of pipe, type of joints, bends, temperature changes, etc., it is doubtful whether Professor Earhart's determinations are of any value outside of the laboratory. For practical conditions, the formulæ derived by T. R. Weymouth from numerous observations and published in Vol. 34 of the Transactions of the Society are unquestionably of sufficient accuracy in problems involving the flow of natural gas.

Referring to Table 1, it appears that the coefficients of viscosity are computed from the coefficient of viscosity for air and the relative coefficients of viscosity as determined on the following page. It is unfortunate that the author has neglected to give sufficient data to permit the checking of these values by the formula preceding the table.

In determining the relative densities by an effluxometer, the densities are in the ratio of the squares of the times of efflux. In view of the fact that the coefficients of viscosity are in the ratio of the times of efflux, the densities should be as the squares of the relative coefficients of viscosity. Using the latter values as given in Table 1, the computed densities as compared to those in the tables are as follows:

Computed.......	1.000	0.593	0.533	0.563	0.540	0.563
From Table 1...	1.000	0.682	0.660	0.660	0.690	0.666
Computed.......	0.504	0.578	0.563	0.672	0.689	.....
From Table 1...	0.585	0.755	0.678	0.755	0.770	.....

P. F. WALKER. The author uses in his title the words "ratio of specific heats," and throughout his discussion shows that he is assuming that this ratio and the value of the adiabatic exponent are identities.

The statement is made at the outset that this paper and the experimental work on which it is based constitute an extension of an earlier paper dealing with the question of the variation of natural gas from Boyle's law. In that paper the joint authors indicate a very marked deviation of the gas from the laws of perfect gases. While the numerical values shown in that paper are excessive, being made to appear large because of some unexplained fluctuations at low pressures which other experiments do not corroborate, it is true that the substance differs materially from a perfect gas.

It is not necessary to go through the steps of the mathematical proof of the principle that for a perfect gas the adiabatic exponent is the ratio of specific heats. It has been my observation on several occasions, however, when questions on this matter were up for discussion, that it is necessary to remind engineers of the fact that the statement applies only to perfect gases. It seems to be an ingrained notion in the minds of technical and scientific men that the adiabatic exponent must be the ratio of specific heats. This is far from being the truth, however, when the gas is of such a character that it fails to follow the laws of perfect gas to such an extent that the variation is worthy of notice. The point brought out in the previous paper by the author, and in substance fully attested to by all who took part in the discussion, is that this gas in its behavior does vary materially from the laws of perfect gases, and hence it must follow that the value of the exponent found for an adiabatic cannot be taken as the ratio of specific heats.

This point is of significance, provided the purpose of the investigator is to discover facts with reference to specific heat. We need not enter at this time into a discussion as to which is the important thing to be determined. Every contribution to our knowledge of matters in this connection is valuable, and we should be grateful to Professor Earhart for having brought this interesting and instructive investigation to our attention.

SANFORD A. MOSS. While natural gas may depart considerably from the perfect-gas laws, at high pressure, the departure at pressures close to atmospheric cannot be very serious. Hence the computation of density and of specific-heat ratio from gas analysis will give reasonably accurate results.

I have made such computations for the various samples given by Professor Earhart in his Table 1, using the volumetric analysis there given. I obtained values for the density and specific-heat ratio which differ greatly from experimental values tabulated by Professor Earhart.

The method of computing density or specific gravity of a mixed gas from the volumetric analysis is well known. It consists in multiplying the percentage of each component by

density of said component at standard conditions, and adding the results. A sample computation of density is given in Columns *C* and *D* in Table 2. The values of specific heat at constant pressure and specific heat at constant volume can be found in a similar way, using, however, analysis by weight instead of analysis by volume. The ratio of the specific heats of the mixture as thus computed gives a value which can be used to compute velocity of sound, etc., and which should agree with the experimental values of Professor Earhart's n.

In other words, if we have a gas mixture containing various components whose individual specific heats at constant pressure are c_p', c_p'', etc., and whose specific heats at constant volume are c_v' c_v'', etc., and if the percentages by weight of each of the components are x', x'', etc., then it can be shown that the specific-heat ratio for the mixture is

$$n = \frac{x' c_p' + x'' c_p'' + \ . \ . \ .}{x' c_v' + x'' c_v'' + \ . \ . \ .}$$

This formula is almost self-evident. However, I have given a deduction in *Sibley Journal*, May, 1905, page 311. A sample computation of specific-heat ratio by this method is given in Table 2, Columns *E*, *F*, *G*, *H* and *I*.

In making computations I have used the values of c_p and c_v listed in Columns *F* and *H*, Table 2. All of these values are fairly well agreed upon by various authorities except the value for ethane, which I was not able to find. However, it is well known that for a perfect gas the molecular specific heat or product of specific heat and molecular weight m, is given by

$$c_p m = \frac{1.97}{1 - 1/n}$$

I have used the value of n for ethane given on the first page of Professor Earhart's paper, and obtained c_p by this formula. The value is of course in error due to the imperfection of ethane, but the discrepancy cannot be very large.

I have made computations similar to those in Table 2 for each of the gas samples given in Professor Earhart's Table 1. A comparison with the experimental results of Professor Earhart is given in Table 3. As will be seen, there is an appreciable discrepancy. I do not believe this can be explained by the fact that the gases in question do not obey the perfect-gas laws.

MR. EARHART'S CLOSURE

R. F. Earhart. A confusion of terms seems to have arisen involving the flow of gases through a pipe. The resistance offered to the passage of a stream of gas through a pipe is a complex problem and, as Mr. Bernard has pointed out, is influenced by the physical condition of the pipes, the joints and several other factors. The coefficient of viscosity, strictly speaking, is a measure of the internal friction of the gas and is but a single factor in the problem. In many cases, no doubt, it is less important than others; it is, however, a factor peculiar to the gas itself.

It appears that in some cases the viscosity effect (or computations for "viscosity" by engineers) is taken to represent the summation of a considerable number of factors. Some of these have been taken into consideration by Mr. Weymouth in the article to which reference has been made.

The experiments on the coefficient of viscosity were made with the idea of comparing the single factor of internal friction or viscosity for gases obtained from widely different sources under similar conditions of pressure and temperature and in the same apparatus. The values obtained cannot, of course, replace those found serviceable in practice and which include several other factors, even though in a very loose way they go by the same name; nor can they be expected to give satisfactory density values.

The rate of escape of a confined gas through an orifice is a function of the pressure, temperature, density and coefficient of viscosity. In the effluxometer we compare the densities of two gases under similar pressure and temperature conditions by the rate of escape through an orifice which must be an opening in a thin diaphragm. To obtain density comparisons, the diaphragm must be vanishingly thin in comparison with the size of the orifice. This is approximated by making a small hole in a piece of thin foil, usually of platinum. The necessity for making the diaphragm thin is to reduce the effect due to viscosity.

Thus, by suitably dimensioning the apparatus, the viscosity effect becomes small and is assumed to be negligible. When, however, we make the diaphragm very thick or for convenience cause the gas to escape through a tube whose length is great compared with the diameter of the opening, the rate of escape is determined largely by the viscosity factor. Practically, when the length of the tube is 200 times the diameter, the viscosity term becomes so large in comparison with the density factor that the density factor is neglected. The conditions which prevail in the two cases are so different that the data

TABLE 2 SAMPLE COMPUTATION OF DENSITY, WEIGHT ANALYSIS AND SPECIFIC HEATS OF A GASEOUS MIXTURE, FROM VOLUMETRIC ANALYSIS

Natural Gas from Vinton County, Ohio, Line 6, Table 1

Component *A*	Volumetric Analysis % *B*	Density of Components, lb./cu. ft. 14.7 lb. Abs. 60° F. *C*	Weight of Components, lb./cu. ft. $= B \times C$. *D*	Analysis by Weight $= D/0.05174$ *E*	c_p of Components *F*	c_p of Mixture $= E \times F$ *G*	c_v of Components *H*	c_v of Mixture $= E \times H$ *I*
CO_2...	0.1	0.11683	0.00012	0.23	0.2020	0.0005	0.1554	0.0004
O_2....	0.8	0.08442	0.00068	1.31	0.2175	0.0028	0.1556	0.0020
CH_4...	73.0	0.04261	0.03111	60.13	0.5920	0.3560	0.4490	0.2700
C_2H_6...	5.8	0.08212	0.00476	9.20	0.4260	0.0392	0.3600	0.0331
N_2....	20.3	0.07424	0.01507	29.13	0.2419	0.0705	0.1835	0.0535
	100.0		0.05174	100.00		0.4690		0.3590

Density of air, 0.07638 lb./cu. ft. at 14.7 lb. abs. and 60 deg. fahr.
Specific gravity of gas, 0.05174/0.07638 = 0.6775
n or c_p/c_v for mixture, 0.4690/0.3590 = 1.306

TABLE 3 COMPARISON OF VALUES OF SPECIFIC GRAVITY AND SPECIFIC-HEAT RATIO OF NATURAL GAS BY COMPUTATION AND EXPERIMENT

Line in Earhart's Table 1	Specific Gravity (Density, with Air = 1.00)		Specific-Heat Ratio n or c_p/c_v	
	Earhart's Experimental Value	Computed Value	Earhart's Experimental Value	Computed Value
2	0.682	0.6503	1.238	1.285
3	0.660	0.6278	1.214	1.294
4	0.660	0.6370	1.209	1.305
5	0.690	0.6622	1.210	1.290
6	0.666	0.6775	1.259	1.306
7	0.585	0.5795	1.285	1.318
8	0.755	0.7320	1.293	1.259
9	0.678	0.6870	1.220	1.278
10	0.755	0.7521	1.290	1.300
11	0.770	0.7760	1.224	1.297

obtained under one set of conditions cannot be treated by the formula applying to the other.

A comparison of density determinations made by different effluxometers indicates that those made in the usual way are not accurate; the discrepancies are sometimes several per cent. The writer is therefore brought to the conclusion that the accuracy of this method is greatly overestimated.

The point raised by Professor Walker concerning the application of the law of perfect gases to the theory of velocity determinations is well taken. The degree of accuracy obtained in the experiment will determine whether the correction factor should be applied or omitted. The value of n is obtained by taking the product of three quantities, one of which is the density of the gas. The density of the gas was determined to one part in five hundred in the laboratory. This is a higher degree of accuracy than conditions really warrant, for gas from any field will show variations from day to day of perhaps one per cent. However, it was easy to determine. This, however, places a limit on the accuracy of the result, and it is not desirable to introduce a correction factor of less magnitude in the other quantities.

The experiment by Mr. Wyer and myself showed that the departures from Boyle's Law were appreciable for several atmospheres' change and were large when the pressure variations were thirty or forty atmospheres. However, when sound waves pass through a gas the pressure changes are from one atmosphere to possibly one and one millionth atmospheres. Even for such a pressure change there should strictly be a correction for deviation from Boyles' Law, which is assumed to hold between the limits of pressure employed.

The application of this correction factor is not justified when compared with the density determinations. The correction applicable in such cases is treated in a very able way by Capstick in a paper presented to the Royal Society of London (Phil. Trans. Roy. Soc. of London, 1894, Part I, Page 1.) Dr. Capstick was determining the ratio n for a series of vapors some of which were but slightly removed from saturation. Under such circumstances the deviations from Boyles' Law are considerable. He made a careful study of the case and found a small correction necessary. The natural-gas products, however, are so far removed from this condition that any modification of the value obtained from direct experiment is not justified.

PULVERIZED FUEL FOR LOCOMOTIVES, J. E. MUHLFELD

C. W. Corning.[1] I am familiar with many of the results from the use of pulverized fuel as stated in Mr. Muhlfeld's paper, having for several months had charge of an Atlantic-type locomotive in first-class passenger service, burning this form of fuel.

Of the many things which contribute toward the lightening of the enginemen's cares in the discharge of their duties, probably the two most essential are the properly working of injectors and the free steaming of the engine.

In all of the runs made by the engine mentioned, it never failed to deliver all the steam pressure required (in the language of the fireman, it is "two o'clock" all the time by the steam gage). In the event of the failure of the injectors it is a simple matter to shut off the supply of fuel until such time as the matter can be remedied and the fire relighted.

A very prominent feature of the pulverized-fuel engine is the fact that the draft appliances need not be changed for different grades of fuel, or climatic conditions of the various seasons of the year. The locomotive has been operated in all kinds of weather, in very heavy rain storms, snow storms, extremely hot and dry weather, and when the temperature was several degrees below zero, and there never was any noticeable change in the steaming qualities of the engine.

Last, but not least, of the many good qualities stated in Mr. Muhlfeld's paper is that of the possibility of enlarging exhaust-nozzle openings. The area of the exhaust-nozzle opening on the C. & N. W. engine has been increased about 40 per cent. In summing up, what is nearest the heart of an engineman is a free-working engine, and this is obtained by burning pulverized coal.

[1] Chief Smoke Inspector C. & N. W. R. R., Chicago, Ill.

W. A. Evans. Only two of those discussing the proposition suggested what has always been the one difficulty in obtaining powdered-fuel combustion under boilers, viz., the difficulty of maintaining the brickwork with its necessity of large combustion space for this form of burning. One of the men stated frankly that his company had experimented with powdered coal, and found when forcing the boiler, as is necessary in locomotive practice, that the brickwork was difficult to maintain. It is hoped that Mr. Muhlfeld will give full account of brickwork difficulties and means by which he would overcome them.

To those who have watched powdered-coal development there was much satisfaction in the apparent success of burning it under a Franklin boiler at the American Locomotive Works in Schenectady, N. Y. That installation seemed to indicate the necessity of large combustion space and slow velocity of fuel and air entering the furnace. These demands are quite contrary to the limited possibilities on the illustrations shown in Mr. Muhlfeld's paper on the application to locomotive boilers. After operating for over two years, to the writer's knowledge there is no evidence that results have been so desirable as to have the other boilers in the same plant equipped with the same fuel apparatus, and two years of experience ought to attract more attention than is evidenced by the lack of further development in the stationary line in this time.

There is further cause for caution on the part of those considering the use of powdered coal in the fact that of the many concerns claiming to produce powdered-fuel equipment and soliciting opportunities to undertake the entire installation, none, to the writer's knowledge, will give a definite guarantee of results.

Lawford H. Fry. Mr. Muhlfeld has shown the economy and advantage of applying pulverized fuel to locomotives designed with a grate for burning lump fuel. It would be interesting if he could tell us what further advantages could be obtained if the locomotive were to be designed from the outset without the restrictions imposed by the necessity of a grate. To see what changes would be involved, consider the difference in the two processes of combustion. In firing lump coal, the fuel is introduced intermittently, being thrown on to a bed of incandescent fuel. The volatile matter is distilled off and burnt in the volume of the firebox. The fixed carbon, or at least the greater part of it, remains on the grate. In order to burn this, a strong current of air through the grate is necessary since, owing to the comparatively small surface of the lumps, it is necessary that they be scrubbed vigorously by the air, using an amount in excess of that which combines

with the carbon during combustion. This process of combustion gives two requirements in locomotive design: sufficient volume for the combustion of the volatile matter, and sufficient grate area for the combustion of the fixed carbon. It is well known that the higher the percentage of fixed carbon, the larger must be the grate, hence the large grate areas necessary for anthracite-burning locomotives.

With pulverized fuel the conditions are, as Mr. Muhlfeld has pointed out, entirely different. The fuel is introduced continuously as it is burnt, not intermittently. Owing to the very large surface which each particle of fuel has in the pulverized form, the scrubbing action of the air is not required, and complete combustion can be obtained with the theoretically necessary amount of air, provided the fuel floats with the air for a sufficient time at the temperature necessary for combustion. It is obvious that with the pulverized fuel no grate area is necessary, but there must be sufficient firebox volume and a sufficiently long travel for the flame to allow complete combustion to take place before the gases enter the flues and are cooled below the combustion temperature. It would be very interest if Mr. Muhlfeld could give us some information as to the volume and length of firebox required for a given rate of combustion.

Now coming to the effect which this novel process of combustion may have on locomotive design: So far as the lump-fuel locomotive is concerned, Mr. C. D. Young in discussing locomotive proportions before the Master Mechanics' Association last June, pointed out that the basic steps in designing a locomotive are, first to determine the grate area necessary to give power, and then to settle on the depth of throat sheet which will give sufficient firebox volume for efficient combustion. The depth of throat sheet in conjunction with the diameter of the drivers fixes the diameter of the boiler which can be used with a given loading gage. This all means that the design for the whole lump-fuel locomotive is built up around, and is controlled by, the grate area and the depth of firebox.

Now with pulverized fuel it would seem to be possible to eliminate both grate and throat sheet, and to use a boiler of larger diameter and special design which would give even better results than can be obtained by adapting an existing lump-fuel boiler. I have not attempted to work this thought out in its practical details, but it would be interesting if Mr. Muhlfeld could tell us whether he has considered this phase of the question of pulverized fuel. Of course a special design of boiler along the lines indicated presupposes complete conversion of the road using it to pulverized fuel, but no doubt Mr. Muhlfeld has sufficient confidence to look thus far into the future.

E. H. Stroud. The results reported by Mr. Muhlfeld show a great advance upon the practice of burning lump coal upon locomotive grates, hand-fired, and an enormous saving to the railroads in many ways. Still better results can be had, however, and a greater saving of coal and money be made by abandoning the use of stack draft, and making all the air necessary for the most complete combustion possible carry into the firebox all the coal that has to be burned.

The statement has been made that it would be impossible to find space enough that could be spared upon the front end of a tender for such apparatus as would be required to do this. Such apparatus, however, is available from my firm, in size to fit that space, and it can be built to operate, at variable speed, by either steam or electricity. It is the result of 16 years of effort and I know of nothing but our method of operation which has been really successful under boilers of any kind. We tried the stack-draft method and abandoned it years ago for the very faults shown by Mr. Muhlfeld's locomotives. They save 15 per cent of coal. Our plan saves nearly 50 per cent in stationary boiler plants, where the usual losses are not so great as in locomotives. By our method we are able also to give furnace temperatures from 1800 deg. fahr. to 3000 deg. fahr. and over, and such a low temperature has not been achieved before.

It is evident from Mr. Muhlfeld's showing that the use of stack draft renders necessary for the control of the fire of a locomotive a much more complicated mechanism than is needed for firing by the method and device I have mentioned, which latter performs for powdered coal the same service as the device called a carburetor performs for gasoline: namely, it receives the entire quantity of the two fuel elements, coal and air, and mixes them thoroughly together in exactly the right proportions before they enter the combustion chamber.

It makes no material difference, therefore, whether the locomotive is standing or running, or what its speed may be, or whether there be wind or no wind, provided it be fired by such a stoker; whereas, when depending upon stack draft the circumstances mentioned must necessarily exert a considerable influence, and require the use of a constantly varying quantity of exhaust steam at all times to counteract those influences, thus putting a back pressure upon the cylinders and reducing the efficiency of the locomotive proportionately.

I think it is admitted by most railroad men that the use generally made of the exhaust steam to create stack draft reduces the total locomotive efficiency 25 per cent. Such being the case, the use of the apparatus referred to would give the locomotive one-third more power to use, besides effecting a greater saving of coal and water and the simplifying of the control of the firebox results, because the exhaust steam will not be used to create draft.

J. H. Manning.[1] Mr. Muhlfeld's paper accords with our practical experience with engine 1200, having a boiler the principal dimensions of which are as follows:

Diameter, first course .... 86 in.
Firebox, size .... 114 in. wide, 126 in. long
Equivalent heating surface .... 5004 sq. ft.
326 2-in. tubes
46 superheater units

This boiler supplied steam to 27 x 32-in. cylinders, and developed through a medium of 63-in. wheels, 60,000 lb. tractive power at the drawbar, carrying 205 lb. of steam.

This company, the Delaware and Hudson, is closely connected with a territory that produces about 80,000,000 tons of anthracite per year. It is not hard to understand that a great deal of extremely fine coal and dust accumulates in the process of marketing. This cannot be burnt on the grates, but, if at all, in suspension in a refractory furnace. For this latter purpose we have available in our neighborhood 550,000 tons per month. This latter and the fact that there were located around us a number of industrial plants successfully burning bituminous coal in pulverized form, encouraged us to build an experimental locomotive of the dimensions stated above, producing approximately 2700 cylinder horsepower. To guard against the possibility of failure, the entire firebox, boiler and locomotive was so constructed that the application of the powdered-fuel mechanism could be readily removed and the firebox, etc., arranged for burning fuel on grates.

[1] Superintendent of Motive Power, Delaware and Hudson Company, Watervliet, N. Y.

We soon found out it would be impossible to burn clear anthracite coal in pulverized form. Due to the low volatile, it would promptly snuff out if the engine should happen to slip or worked extremely hard, and firebox temperature would not permit it to again flash. We therefore arranged a program and determined to start with 75 per cent bituminous and decrease until it was found that this objectionable feature was removed. This was continued until a mixture of 60 per cent anthracite and 40 per cent bituminous was obtained. We find this gives splendid results, the engine steams freely with very little smoke and is very nicely controlled by the fireman to the extent of keeping the engine within three pounds of the maximum pressure continuously without popping under the different operations necessarily obtaining in a day's work with an engine of this character, experiencing no firebox trouble whatever.

Such difficulty as we have had with the pulverized-fuel mechanism for the introduction of the fuel into the firebox has been satisfactorily eliminated and the successful burning of pulverized fuel in suspension in locomotive firebox, to my mind, has passed beyond the experimental stage. It is now a question of economy only and this depends upon the source of supply in a great measure.

MR. MUHLFELD'S CLOSURE

J. E. Muhlfeld. With respect to the points that Mr. Robinson brought out, I would say that he has looked at this matter from a strictly practical standpoint, and, in my opinion, the advantages that he names, through ability for the railway to pool the various grades and qualities of coal that they secure from the different mine operations along their line, reduction in fire building, ashpit and other terminal delays, and the elimination of arduous labor on the part of the fireman, are among the most important items with which the railways are contending today. The advantages of pulverized fuel with regard to all of these have already been demonstrated in road and terminal operation.

Mr. Katte took exception to paragraph *d* under the caption Facts and Conclusions. If, as he states, the electric locomotive and the complete electric installation behind it for the movement of heavy traffic over long distances can be maintained and operated cheaper than the equivalent steam unit, then we would like to have some figures to show it. As the steam locomotive carries its own self-contained power plant, its maintenance cannot be compared with an electric locomotive that does not generate its own power. A fair comparison must cover the combined fixed charge, maintenance and operating expense involved for drawbar horse power per hour.

Mr. Katte felt that the electric installations so far made have demonstrated greater reliability under all conditions than steam locomotives. In reply to this it might be interesting to make a comparison of steam-railway steam-locomotive operation for from 25 to 30-mile runs in the Chicago district with steam-railway electric-locomotive operation for similar distances in the New York district as regards schedule time and regularity and continuity of service, summer and winter. With respect to flexibility of service, a steam locomotive can be operated wherever the gage and strength of the track admit it, whereas an electric locomotive is confined to the electrified section that fulfills its electric-current characteristics and contract-line requirements. In the January 8, 1916, issue of the *Railway Review*, I covered this phase of the subject in considerable detail in a paper entitled The Future of the Steam Locomotive, the majority of the data presented having been obtained from about five years of actual experience with steam- and electric-locomotive operation on the Baltimore and Ohio Railroad.

The point that Mr. Fowler makes about more constant firebox temperature with pulverized fuel is certainly correct, as the firedoor is never opened during the time that combustion takes place, and the liability of a cold shaft of air passing through the firebox, as where coal is burned on grates, is entirely eliminated.

Mr. Young refers to work that the Pennsylvania has done and which, from results obtained with a locomotive in a stationary condition, must have been with entirely different means, methods and processes from what we have developed and make use of in both locomotive- and stationary-boiler practice. Their arrangement evidently concentrates or pockets the heat in connection with the refractory material, and too great a velocity pressure of the products of combustion must obtain in the firebox.

Mr. Young also brought out that the Chicago & North-Western locomotive water-rate performance was exceptionally high. He evidently considered this from a cylinder-horsepower, rather than from a drawbar-horsepower-per-hour standpoint.

With respect to his statement that from 40 to 60 per cent of the fuel consumed by steam locomotives, when coal was being burned on grates, takes place when the engine is not working steam: Our data in this regard, obtained from actual road results, are in accord with his figures. Of course, the more congested the operation on a right-of-way, as for example, during the past few months on various steam roads in the Eastern district in the United States, the greater this percentage becomes.

Mr. Randolph brought out the matter of liability of dust explosions. From the fact that about 8,000,000 tons of pulverized coal are now being burned in the United States per annum, it is thought that general practices with respect to the handling, drying, pulverizing, storing and disbursing of the same have been pretty well taken care of, and the general results with the various cement and industrial plants using this kind of fuel indicate this to be the case. Where we have had our designs of fuel-preparing, handling and burning equipment installed, up to the present time no trouble whatsoever has obtained.

Mr. Basford's idea of prolonging the life of existing locomotives by modernizing them through the application of pulverized fuel was well taken, and an enormous amount of work remains to be done along this line which will enable the reclaiming of motive power that in its present condition is ineffective and uneconomical.

Mr. Baker brought out the problem of smoke elimination, particularly in the larger city terminals where numerous switching and transfer locomotives are used.

The control of not only the smoke, but also of sparks, cinders and popping off, as well as the reduction in the exhaust-nozzle noise is entirely possible and practicable with the development that has already been demonstrated through the operation of the Chicago & North-Western pulverized-fuel-burning locomotive in the City of Chicago.

The items that Mr. Corning brought up were those which appealed to the practical railway operating official as well as to the engineer and firemen in charge of the locomotive, and the benefits to be derived from flexibility in the operation of the equipment and the maintenance of economical working steam pressure at all times and under all conditions, and further the increased tractive power by the enlargement of the exhaust-nozzle area are most essential in that regard.

Mr. Evans brought up the difficulty in maintaining brick-

work, with the necessity for large combustion space in the use of powdered fuel in boilers, and requested data on that subject. The answer is: Reduce the velocity pressure of the combustion gases to the minimum; eliminate restricted areas in the brickwork through which these gases must flow; and bring these gases into contact with heat-absorbing surfaces as quickly as possible after the combustion process has been completed. We have found that owing to the rapidity of oxidation large combustion space and brick area are not necessarily essential to effective results.

Probably the reason for Mr. Evans not being able to secure a definite guarantee of results from the use of pulverized fuel from the concerns with whom he has had the matter up, is the fact that until recently very little practical knowledge has been available on which to base such assurances, and that essential means, methods and processes were not really developed along practical lines until the application of pulverized fuel to the most unfavorable condition, i. e., the steam-locomotive boiler, was undertaken.

Mr. Fry brought up the question of volume and length of service locomotive firebox necessary for a given rate of combustion. All of our development work has been done with existing standard designs of locomotive fireboxes and boilers ranging from 48 in. wide by 90 in. long, to 114 in. wide by 126 in. long, and in no instance has there been any difficulty experienced with burning the requisite amount of fuel to secure economical boiler horsepower under the most extreme working conditions. This applies to lignite as well as to bituminous coal and to a mixture of 60 per cent of anthracite slush and 40 per cent bituminous screenings.

The point that Mr. Fry brings up relative to being required, when coal is burned on grates, to build up a locomotive design around the grate-area and depth-of-firebox dimensions, is largely correct, and the burning of fuel in suspension will enable the use of special designs of locomotive boilers, for example, for longer flameway and return tubes, which will permit of utilizing a much greater percentage of the fuel value than will ever be found possible by the burning of fuel on grates.

Mr. Stroud points out the feasibility of securing still better results than what have been obtained by abandoning the use of stack draft. The practical work that we have done along this line has, to the present date, not demonstrated this. While stack draft is not needed to secure combustion results, it is required to produce boiler and superheater capacity and effectiveness, which all-important factors Mr. Stroud has apparently overlooked.

Mr. Manning brings up that on his road a mixture of 60 per cent of anthracite and 40 per cent of bituminous is now giving splendid results in locomotive service. I desire to elaborate on this and state that the 60 per cent consists of anthracite slush, or heretofore waste by-product of mining, and that the 40 per cent consists of bituminous unwashed screenings, all of which is mixed and pulverized.

This mixture gives a fuel of about 15 per cent volatile as compared with the heretofore generally recommended practice of not less than 30 per cent volatile. Furthermore, this result has been acquired with the second type of furnace refractory arrangement tried out, and we feel that the next change in the refractory arrangement will result in the utilization of a mixture of at least 80 per cent of anthracite slush and 20 per cent bituminous screenings, for the reason that no difficulty whatever is now experienced in burning the straight anthracite slush in stationary boiler practice and obtaining the requisite boiler capacity and maximum efficiency.

WATER FOR STEAM BOILERS, ITS SIGNIFICANCE AND TREATMENT, ARTHUR C. SCOTT AND J. R. BAILEY

S. B. Applebaum[1] This paper and discussion confine themselves to the old lime-soda system which has been in use about half a century and from which little that is new can be expected. No mention is made of the "Permutit" process which has so rapidly come to front in the last decade in Germany, France and England, and during the last few years in this country. This is an entirely new departure in water softening and it represents the only real progress made in a considerable period.

The essential characteristics of this process are that the water passes through a bed of insoluble exchange alumino-silicates or zeolites at a high rate, and that in the cold a chemical exchange automatically takes place between the water and this material, whereby all the calcium and magnesium are completely removed and replaced by sodium. It is a rapid chemical reaction between the insoluble powerful reagents and the water, which is a very dilute solution of calcium and magnesium salts. The insolubility of these exchange silicates in water is the essence of the process. Because of this property it is possible to remove all of the hardness from water and to obtain this result by automatic filtration. Why is this not possible with the older process? Every chemical reaction to be carried very near to completion needs a driving excess of the reagent. When we add lime and soda ash to water, they dissolve in the water. To remove all of the hardness we would have to add a large excess which would remain in the effluent. Such an excess would be out of the question from the point of view of operating costs, especially today with soda ash at 2½ to 3 cents per pound; and the high causticity in the treated water would make it unfit for boiler-feed use.

The exchange silicates are placed in the steel filter shells in amounts many times in excess of that required by the reaction. But they are insoluble, and as the water flows through the bed of silicates the excess of the latter drives the softening reaction to completion in a few minutes; the effluent comes out of zero hardness and no causticity is present.

The advantages of this process may be summed up as follows:

1 No chemist is needed to analyze the varying compositions of the raw water and proportion the chemicals accordingly. The water passes through the softening material automatically and can never be overtreated.

2 The reaction takes place in a few minutes. With soluble chemicals three to six hours are needed to allow the reactions to take place. Accordingly large settling tanks are needed. These occupy considerable floor space. The Permutit filters for the same service are small and compact.

3 No precipitates are formed and no sludge has to be removed. The liquors from the regeneration are all fluid and run into the sewer.

4 The only cost of operation is that of the salt used for regeneration of the exchange silicates. It is much more economical than the use of soda ash for the removal of permanent hardness.

5 Finally a water free from causticity and having zero hardness is obtained at all times which deposits absolutely no scale.

[The remainder of the discussion on this paper will appear in the March issue of The Journal.]

[1] 30 East 42nd Street, New York City.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members of The American Society of Mechanical Engineers are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal, or brief articles of current interest to mechanical engineers.

Strength of Boiler Furnaces

To the Editor:

In the October, 1916, issue of The Journal, I have read with considerable interest an article by Prof. John Airey, the purpose of which apparently was to expose the inadequacy of the flue formulæ, as regards safety, of the A. S. M. E. Boiler Code by comparing the results of these formulæ with some other flue formulæ promulgated by various authorities.

As the writer has had the advantage of figuring allowable pressures on a very large number of flues covering practically all varieties of sizes actually in use, and also knows from close personal touch with accident statistics in this country that flue failures due to structural weakness as known by theoretical determination contribute a microscopically small proportion of the total number of flues collapsed, he is quite certain that Professor Airey's criticism of the A. S. M. E. Boiler Code formulæ is not warranted. In fact, it seems entirely misplaced, since, judging from what still is actual practice in this country as regards allowing pressure on flues, the A. S. M. E. Boiler Code formulæ appear ultraconservative and their prime virtue is that they are consistent with the most up-to-date and thorough research on this phase of mechanics. Professor Airey's reference to *the danger* of the A. S. M. E. Boiler Code formulæ would therefore seem almost humorous, especially when it is considered that flue failures, aside from those cases of flues that come down due to overheating in connection with excessive amounts of oil entering boilers, are very rare.

It would further appear that Professor Airey's observations of the pressures allowed by other authorities are not correct in several instances, tending to reveal a lack of familiarity with the subject.

Taking up Professor Airey's comment on some of the various rules quoted, I would call attention to the fact that Fairbairn's rule is based on experiments with wrought-iron tubes that were lap-riveted and brazed, so that further allowance for the weakening effect due to a riveted joint is obviously not necessary, especially when making comparisons. This rule is, however, inconsistent in that it permits of pressure determination on flues of any length and produces pressures for long flues that are very low and for the shorter flues excessively high.

The fact has been quite definitely established that for lengths of flues over about six times the diameter, any increase in length for a given diameter does not materially decrease the collapsing pressure.

By a series of tests, conducted on a most exhaustive basis, Prof. R. T. Stewart found this formula for some conditions to err as much as 400 per cent. (Trans. Am.Soc.M.E., 1906, Vol. 27).

In the book written by Hutton no mention is made of the fact whether the flues tested, on which he based his formula, were riveted or welded, but judging from their size and the time this took place, it is fairly safe to assume that they were riveted flues, so that the weakening effect of a joint does not have to be separately taken into account, as it certainly never is in practice.

Hutton's formula has the same faulty characteristics as that of Fairbairn, which has led to the use of the length of riveted sections for L in the formula instead of the total length of flues that are made up in sections by means of lap-riveted girth seams. By doing this, an allowable working pressure that seems more reasonable and which sometimes may still be considered safe is obtained on long flues.

Plain furnace flues of the length given in the concrete case submitted by Professor Airey, namely, 94 in., were rarely made in one length, so that a large majority of the flues at present in use have pressures allowed on them as based on this practice of taking the length of sections for L. In some cases the pressure resulting appears unduly high.

This practice of using the length of sections for L is still followed more or less to this day in the manufacture of inferior grades of boilers and other pressure vessels.

Needless to say, the Code formula gives pressure results considerably lower than the values obtained in the manner just mentioned with Hutton's rule.

The German Government rule is not quoted by Professor Airey in its entirety. This rule reads as follows:

$$t = K \times \sqrt{(P \times L \times D)} + 0.1 \text{ cm.}$$

The constant 0.1 is for boilers in river steamers. For boilers in sea vessels this constant is 0.2. The extra thickness resulting from this augmented constant is required to offset the stronger corrosive action in boilers on board sea vessels due to the possibility of salt water entering them. Quite obviously, for the purpose of making a comparison with the requirements of the A. S. M. E. Boiler Code, which is intended for stationary practice, it would appear that 0.1 is the proper constant to use instead of 0.2, as was done by Professor Airey. On the flue mentioned in the concrete example (29 in. diameter, 94 in. long, $\frac{1}{2}$ in. thick), by using the constant 0.1 the pressure becomes 90 lb. against 75 lb. as calculated by Professor Airey.

Lloyd's rule, $P = \dfrac{89{,}600 \times t^2}{L \times D}$, used to be quite generally employed in the United States for riveted flues, but is now more or less in the discard. Wherever it is still prescribed, as, for instance, in the boiler rules of the City of Philadelphia and other rules that were designed to cover the early practice of boiler construction, the length of the lap-riveted sections may be taken for L, which in some cases has led to absurdly high pressure allowances.

In the practice of applying Lloyd's rule it was never customary to make a special allowance for the character of the longitudinal seam, speaking with regard to American practice at least, and this certainly is not done now in localities where this rule is still used.

The U. S. Government rule (Steamboat Inspection Service) is not identical with Lloyd's rule as stated by Professor Airey,

the latter having been abandoned about 10 years ago. The present U. S. Government rule is

$$P = \frac{51.5}{D}\left((18.75 \times T) - (1.03 \times L)\right)$$

This is the same formula as given in the A. S. M. E. Boiler Code for flues of which the length is 120 times the thickness of the plate or less.

According to this formula the pressure on the flue of the concrete example would figure 94 lb. safe working pressure. There is no stipulation in connection with this formula regarding the weakening effect of longitudinal seams, and consequently the pressures on all boilers in steam vessels where this rule happens to be the deciding factor are never determined making such an allowance; and it may be said in this connection that (to quote the Government Rules) such "plain circular riveted flues, furnaces and cone tops" are quite generally lap-riveted.

The fact that the U. S. Government rule allows for L in the formula to be taken the length of lap-riveted sections causes pressures to be used that appear entirely out of proportion in some cases of very long, thin flues.

The British Board of Trade rule is not correctly quoted by Professor Airey. He quotes it as:

$$P = \frac{75{,}000\, t^2}{(L+1)D}$$

The constant in this formula may be taken at 77,000 for steel flues with single-riveted lap seams. This brings the pressure on the flue in the concrete example up to 75 lb.

There is no provision that the length of riveted sections may be taken for L in this formula, but there is a stipulation limiting the pressure on plain flues to $\frac{9900 \times t}{D}$ lb.

Since the British Board of Trade allow various constants in their flue formula relative to the type of joint, it is, of course, not necessary for Professor Airey to make further allowances for the weakening effect of a single-riveted lap seam as he did, as this is taken care of by the constant.

Summarizing the results of the various rules taken up here in the light of their practical application as stated, we get:

	Working pressure
Fairbairn Rule	155 lb. per sq. in.
Fairbairn Rule (modified)	125 lb. per sq. in.
Hutton's Rule	120 lb. per sq. in.
German Government Rule	90 lb. per sq. in.
Lloyd's Rule	99 lb. per sq. in.
U. S. Government Rule	94 lb. per sq. in.
Michael Longridge Rule	157 lb. per sq. in.
British Board of Trade Rule	75 lb. per sq. in.
Average	114 lb. per sq. in.
A. S. M. E. Boiler Code Rule	99.7 lb. per sq. in.

Of course, as pointed out in the foregoing, the fact that some of the above-mentioned rules allow the length of lap-riveted sections to be used for L, in the case of flues so constructed, changes the values of pressure as given considerably; if, for instance, the flue of the concrete case under discussion were made in three sections that were joined by single-riveted lap girth seams, we would get allowable working pressures as follows:

	Working pressure
Hutton's Rule	208 lb. per sq. in.
Lloyd's Rule	296 lb. per sq. in.
U. S. Government Rule	209 lb. per sq. in.
Average	238 lb. per sq. in.
A. S. M. E. Boiler Code Rule	99 lb. per sq. in.

It is particularly in this feature of taking for L in the various formulæ the length of riveted sections, that the A. S. M. E. Boiler Code rules are a marked improvement, as this is specifically prohibited for the Code formula. (See interpretation by the Boiler Code Committee in Case No. 22, The Journal, January 1916, Page 44.)

It is extremely doubtful whether in the majority of cases one is justified to consider the reinforcing effect of a single-riveted lap seam connecting the sections of a riveted flue, sufficient to disregard the total length of the flue and simply consider the greatest length as that of one section, the same as is done when the sections of a plain furnace flue are joined by the Adamson-ring construction or similar reinforcement, especially so when such flues built in lap-riveted sections are quite long, say 5 or 6 times the diameter.

A few examples of actual flues may serve to further show the conservative amount of pressure allowed by the A. S. M. E. Boiler Code formula and what it has heretofore been quite generally the practice to allow, by taking for L the length of sections, according to Hutton's, Lloyd's and the U. S. Government rules.

58½ In. Length. 2 Sections. 26 In. Diameter. ⅜-In. Plate

	Working pressure
Hutton's Rule	135 lb. per sq. in.
Lloyd's Rule	198 lb. per sq. in.
U. S. Government Rule	163 lb. per sq. in.
Average	165 lb. per sq. in.
A. S. M. E. Code Rule	103 lb. per sq. in.

88½ In. Length. 3 Sections. 24 In. Diameter. ⅜-In. Plate

	Working pressure
Hutton's Rule	146 lb. per sq. in.
Lloyd's Rule	213 lb. per sq. in.
U. S. Government Rule	176 lb. per sq. in.
Average	178 lb. per sq. in.
A. S. M. E. Code Rule	72 lb. per sq. in.

100½ In. Length. 3 Sections. 24 In. Diameter. ⅜-In. Plate

	Working pressure
Hutton's Rule	137 lb. per sq. in.
Lloyd's Rule	188 lb. per sq. in.
U. S. Government Rule	167 lb. per sq. in.
Average	164 lb. per sq. in.
A. S. M. E. Boiler Code Rule	63 lb. per sq. in.

H. J. Vander Eb.

Hartford, Conn.

Friction Screw Presses

To the Editor:

In the July, 1916, issue of The Journal attention is called to an article treating Pressure Developed by Friction Screw Presses, which appeared in one of the trade papers.

While my firm furnished the author at his request some photographs showing the presses it manufactures, I do not

wish the impression to prevail that the theory developed covers our conception of the subject, and that the value of our product be gaged thereby.

Practically every deduction of the author is wrong and the readers of The Journal may be misled by this article.

The formula for the coefficient of efficiency of the screw is unnecessarily complicated and moreover not correct as it assumes that the end-thrust friction acts on a lever r_2 while only $2r_2/3$ should be used.

The formula should have the following form:

$$N = \frac{t_g\ \alpha}{t_g\ (\ \alpha + \varsigma\ ) + \dfrac{2\ Fr_2}{3\ v_1}}$$

α = mean angle of thread.
ς = angle of friction.
F = coefficient of friction.
r_1 = radius of screw.
r_2 = radius of thrust pivot.

The other formulae, such as those of the energy of the flywheel and pressure developed, are also incorrect.

In the example the author accomplished the remarkable feat of calculating the pressure developed by a press by using a formula containing a constant based upon the dimensions and physical properties of the workpiece, and obtains this constant from the dimensions of the press.

Newark, N. J. E. W. Zeh.

Systematic Committee Work in Technical Societies

To the Editor:

The paper submitted by Mr. Hathaway on a Proposed Plan for the Activities of the Machine Shop Practice Sub-Committee of The American Society of Mechanical Engineers[1] contains certain suggestions that have a far wider scope than his title indicates. While, therefore, the discussion below has been brought out by his paper, I would prefer a more representative title, such as Systematic Committee Work in Technical Societies, with Special Reference to Research Work.

Mr. Hathaway says: "The proceedings of such (scientific and technical) societies should provide authoritative and usable data covering the entire range of activities in their respective fields."

Farther on Mr. Hathaway, in elaborating on his idea, says: "A second and even larger undertaking would be the prosecution along predetermined lines of research that would result in definite advancement of the art. At present this is almost entirely left to the enterprise of individuals or companies and there is no coördination of effort."

To a certain extent work of this sort is already being carried on by various societies, including our own. In order to write more by the card I shall confine myself at first to our own work.

We have within our Society:

The Committee on Technical Research. This is the logical agency to which investigation and experimentation for advancing the arts should be entrusted. Special work is naturally carried on by suitable sub-committees created from time to time and existing until their work is completed and gathered into a final report. The main Committee itself should be a permanent or "Standing" one.

We already have a *Research Committee.* As a research committee it is and can be little more than a name. Research and no funds make a poor combination. That is a joke and a rather *poor* joke at that, whether taken in the literal or punning sense. This is no doubt partly because the Committee is not active and does not ask for adequate funds, and it probably does not ask for funds because it is doubtful of those being granted. Inverting the old saw is also a truth: "Ask not and ye shall receive not." It is expecting too much of a Finance Committee to have to provide in its budget, already unable to comply with demands, for funds not asked for. Even so, the Finance Committee does recognize the Reseach Committee's needs by providing the munificent sum of $300.00. (See the report on page 1018 of the December Journal.)

The various *Standards Committees* provide another agency within our Society that does sometimes concern itself with certain phases involving research, but in too haphazard and uncorrelated a manner to secure the best work at the least cost. While standardization is necessarily based more or less on research, research *per se* is not a function of standardization.

Special Committees are occasionally appointed to deal with certain definite subjects, not standards. In much of their work they could be aided by an adequate Research Committee.

A Suggested Plan. We already have a Research Committee. This should be a general supervising committee, not one that actually carries on research. It should originate or pass on projects for research brought to its notice and advise the Council as to the creating of sub-committees, each to deal with one special line only. It would supervise the work of the subcommittees and the expenditure of funds allotted them. It would, on occasion, bring about coöperation with other bodies from other societies, and secure coöperation of the Committees of our own Society, such as certain Standards and other Special Committees. As to funds, these should be allotted as liberally as our budget permits; it is reasonably fair to assume that funds will be furnished for researches that have a special as well as a general interest, without taxing the Society's budget. Care and tact will have to be exercised to guard against the Society's being improperly used and exploited and lending its name to private enterprise.

Precedents. Attention has already been called to the existence of these within our own organization, though limited, fragmentary and without real unity of purpose. The situation is similar in other societies. The British engineers have come nearer to good coöperation research in connection with the work of their Engineering Standards Committee, made up of representatives of the large engineering societies, coöperating with the great engineering firms and with the government.

Probably no one technical society comes nearer to taking care of the problem than the Verein Deutscher Ingenieure, possibly because that society has funds sufficient to enable it to carry on investigation. I can speak with some degree of familiarity of one example that comes within my personal knowledge and of which I was reminded by Mr. Hathaway's reference to Mr. Fred W. Taylor's work reported in his paper On the Art of Cutting Metals. In the early days when Mr. Taylor's high-speed steels, as well as those of Boehler Bros. and the Bismarck Huette, began to attract the attention of the builders and users of machine tools, the Verein recognized their enormous potentialities. A committee was formed, at first under the writer's chairmanship, and a program of experimentation was laid out. Uniform report sheets were dis-

[1] The Journal, December 1916, page 972.

tributed among the largest machine shops about Berlin, and on these was recorded during six months the tool history of all the regular work going through those shops. This enormous mass of data was then classified and digested. (Owing to the writer's being too fully engaged, he relinquished the chairmanship to the very able direction of Mr. Lasche, chief engineer of the Allgemeine Elektrizitäts Gesellschaft.) This gave exceedingly valuable information in connection with the average as well as the highest type of then existing machine tools. The ultimate possibilities of the steels as they were then were determined by a series of tests carried out directly under the writer at the works of the German Niles Tool Works Company, on heavy machine tools specially arranged with a very wide range of speeds, feeds and power. Special steel ingots for turning down were provided and many tons were reduced to chips. With these tools also researches were carried out along lines indicated by the digest of the data gathered in the various shops.

I refer to this somewhat at length to draw attention to the fact that it has been recognized by at least one engineering society that research of this character is quite within its province, that it should be coöperative rather than left to individual effort, that it can be effectively carried on by such coöperation, and that effective aid and coöperation for the general benefit can be secured also from private interests which are quite ready to recognize that though their aid is to some extent altruistic, it is also, as are most truly altruistic efforts, directly beneficial from a personally selfish viewpoint; and that is why such research work, properly undertaken and organized, may count on financial support that need in no way embarrass the Society.

Henry Hess.

Philadelphia, Pa.

Impact or Shear Tests

To the Editor:

In a letter on Impact or Shear Tests published on page 1001 of the December, 1916, issue of The Journal, Mr. John Younger quotes myself as pointing out, in a paper before the American Society for Testing Materials, that "it was very strange that ingot iron or very-low-carbon steel showed greater energy necessary to shear than did the higher-grade chrome-nickel alloy."

The exact words of my paper on Impact Testing, read before that society, were as follows: "By comparing Tables II and III it will be seen that there is no easily discovered relation between the results of impact tests and those of tension tests. For example, ingot iron with low tensile strength and high ductility gives nearly as good impact results as the chrome-nickel steel of high tensile strength and rather low ductility."

No other comment is needed than a comparison of the above quotation with Mr. Younger's indirect quotation.

D. J. McAdam, Jr.

Annapolis, Md.

Engineering Societies and Public Affairs

To the Editor:

Mr. W. Herman Greul's communication appearing in the November issue of The Journal has my decided interest. Mr. Greul has apparently entirely missed or, rather, misconstrued my suggestions on "the relation of engineering societies to public affairs." As a matter of fact, Mr. Greul is far more in accord with my position than he seems to realize. Nowhere did I suggest that the engineer or the engineering societies should adopt the "wait-till-they-ask-me" position.

Quite the contrary, it is distinctively the function of the engineering societies to concern themselves with public affairs and I have advocated that, but to restrict that concern to the engineering phase while steering clear of politics.

Possibly the strongest proof of this situation is the A.S.M.E. Boiler Code matter that I also cited in my original communication. The American Society of Mechanical Engineers, in association with other engineering bodies, not only did not wait until it had been approached, but it took the initiative in working up a basic engineering code governing the construction of boilers. The thing that the Society did not do in this connection, and upon which the Society has gone on record as being outside of its province, was the formulating of laws relating to the adoption of the Code by municipalities and legislatures.

Those who are most familiar with the work that the Society did do in the working up of this Code, those who know of the weeks of continuous sessions, frequently lasting late into the night, that the original Committee and its consulting committee held, will be most emphatic in their conviction that the Society did, of its own initiative and from within, undertake most vitally constructive work connected with public affairs.

It is rather difficult to see just how this attitude of the Society can be interpreted as the engineering societies' being "afraid they cannot measure up to the requirements of such a progressive attitude" and "stay on our pedestal where we will not encounter the difficulties of constructive, aggressive work." Surely if ever any constructive work was done by an engineering society, this Boiler Code deserves that name; such constructive work was distinctly and most decidedly constructive engineering, and it would be difficult to see in what way the engineering societies can be of more use to the community than along just such lines; and it is work of this sort which was most distinctly advocated in my article.

Henry Hess.

Philadelphia, Pa.

In the *Journal of The Franklin Institute*, January 1917, is described a machine of high precision for testing the speed and efficiency of shutters in photographic apparatus, developed by the research laboratory of the Ansco Company. In this machine a simple method has been found to overcome the difficulty due to overlapping of the image in the case of shutter exposures of more than 1/50 sec.

In *The Engineer*, December 29, 1916, is presented a brief description of reinforced-concrete floating structures which have been widely employed of late. In the past, similar structures were built but they were not intended to float continuously. The article, among other things, recalls the fact that as early as 1912 a pontoon was built for the Manchester Ship Canal 100 ft. long and 28 ft. wide, to draw about 5 ft. 6 in. of water when fully loaded, and to act as a movable pumping plant which is shifted from place to place as may be desired and which is used for pumping material dredged from the canal on to any low-lying land near the banks which it may have been decided to raise.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees. Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

THE features of the month just closed are the meeting of the Civil Engineers in the Engineering Societies Building, noted elsewhere in this issue, and the President's visit to the Sections.

The former means much to your Secretary for the reason that it was his privilege, fifteen years ago, to receive the gift of $1,500,000 from Mr. Carnegie for the Engineering Societies Building. This was addressed to the four engineering societies and the Engineers Club jointly, and on account of the unwillingness of the Civil Engineers to accept at that time, the whole gift was jeopardized until Mr. Carnegie consented to readdress his gift to the other organizations omitting the Civil Engineers.

The President has undertaken to visit all of the Sections at some time during his administration and by that act develop a national interest and spirit. In addition to his visits made to the Sections this month, reported elsewhere in this issue, he has also addressed a number of other organizations, and the underlying thought in all of these addresses has been to emphasize the service of the individual to society.

CALVIN W. RICE, *Secretary.*

Council Notes

The regular meeting date of the Council has been changed to the third Friday of the month, in January falling on the 19th. There were present at this meeting, Ira N. Hollis, President, presiding, C. H. Benjamin, W. B. Jackson, C. T. Plunkett, Charles T. Main, Arthur M. Greene, Jr., R. H. Fernald, John A. Stevens, D. S. Jacobus, Wm. H. Wiley, *Treasurer,* Max Toltz, F. R. Hutton, Calvin W. Rice, *Secretary* and R. M. Dixon, *Chairman Finance Committee.*

L. P. Alford, F. E. Rogers and George B. Brand were appointed a Committee on Award of the Junior Prize for 1917, and W. D. Ennis, D. S. Kimball, and F. R. Hutton were appointed a Committee on Award of Student Prizes for 1917. Particulars of these awards appear elsewhere in this issue.

The Council has approved the setting ahead one day of the Spring Meeting, 1917, to permit of a joint session with the Machine Tool Builders Association. The meeting will be held in Cincinnati, May 21 to 24.

The Boiler Code Committee has been reappointed for 1917. This committee has lost by death H. G. Stott and one member by resignation.

The President announced the following appointments on Standing Committees of the Society:

Finance............W. E. Symons, to serve for 5 years
Meetings..........A. L. DeLeeuw, to serve for 5 years
Publication......George J. Foran, to serve for 5 years
Membership..W. C. Morris, to serve for 4 years, Nicholas S. Hill, to serve for 4 years
Library............A. M. Hunt, to serve for 4 years
House...............H. O. Pond, to serve for 5 years
Research........Albert Kingsbury, to serve for 5 years
Public Relations......................To be appointed
Constitution and By-Laws....Ira H. Woolson, to serve for 4 years, Jesse M. Smith, to serve for 5 years
Standardization......Henry Hess, to serve for 5 years

I. E. Moultrop has been appointed on the Board of Trustees of United Engineering Society, to fill the vacancy in the Society's representation on the Board caused by the death of Mr. Stott.

A special committee consisting of J. W. Lieb, F. R. Hutton and D. S. Jacobus was appointed to prepare resolutions in token of appreciation of the signal contribution to the society's work rendered by Mr. Stott in his service as an officer of the Society, as a member of professional committees, and as the Society's representative in many undertakings.

Special resolutions were recorded thanking the Engineering Foundation, and in turn the Founder Societies, for the assistance which has been given to the National Research Council in its work. These resolutions follow:

WHEREAS The Engineering Foundation, administered by the American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineeers and the American Institute of Electrical Engineers, out of public spirit and with a desire to increase the intimacy of the relations between the research workers and the engineers of the United States, has generously put its whole resources, its office facilities and the services of its Executive Secretary at the disposal of the National Research Council in order to assist the federation and coördination of governmental, educational, industrial and other agencies of research, and

WHEREAS the assistance of The Engineering Foundation thus tendered has been gratefully accepted; now, therefore, be it

Resolved, That the thanks of the National Research Council for this assistance be hereby expressed to The Engineering Foundation and through it to the United Engineering Society and to the American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineeers and the American Institute of Electrical Engineers, and it is further

Resolved, That the National Research Council reciprocates and hereby expresses the desire for closer relations between the research workers of the United States and the members of the engineering profession constituting the national engineering bodies, and it is further

Resolved, That the Secretary of the National Research Council be instructed to transmit a copy of these resolutions to The Engineering Foundation, to the United Engineering Society and to the governing bodies of the national engineering societies above mentioned.

Attest CARY T. HUTCHINSON, *Secretary.*

W. B. Jackson, member of the Council and past-president of Board of Directors of the Western Society of Engineers, presented the request of that society that the Council appoint two representatives on the Washington Award administered by the society to be annually presented to an engineer whose work in some special instance, or whose services in general have been noteworthy for their merit in promoting the public good. The President has been requested to nominate two such representatives.

CALVIN W. RICE, *Secretary.*

CIVIL ENGINEERS MEET IN ENGINEERING SOCIETIES BUILDING

THE Sixty-Fourth Annual Meeting of the American Society of Civil Engineers, now a Founder Society, was, by invitation of the United Engineering Society, held in the Engineering Societies Building. Plans of the addition to the building to house the Civil Engineers and a model showing how the building will look when completed were available at the meeting for inspection. The meeting was held on January 17 and 18.

In calling the meeting to order, President Clemens Herschel introduced Mr. Charles F. Rand, President of the United Engineering Society, who "welcomed the Civil Engineers to their own home." Mr. Rand said:

"As one who has looked forward very earnestly to this day and who has made a modest effort in favor of the new arrangements, it is a peculiar satisfaction to be the representative of the Trustees of the United Engineering Society and to welcome you on the occasion of your first meeting in this building in which you now own a quarter interest.

"As this is your annual meeting, I cannot take your time for extended remarks, yet it seems proper that I should call attention to a few facts respecting the United Engineering Society with which you are now identified.

"The U.E.S. exists for the purpose of holding the legal title to certain of the property of the Societies of Civil, Mining, Mechanical and Electrical Engineers, and to act for them in certain matters. The value of its property, including real estate, the Library and the Reserve and Endowment Funds exceeds two million dollars, all free and clear.

"The total membership of the four Founder Societies is 29,000 and the membership of associate societies is 23,000, making a grand total of 52,000 engineers who now have headquarters in this building.

"As is well known the U.E.S. stands not over but under the Founder Societies. It is organized to perform for the Founder Societies certain specific acts which are governed by contracts. There is no merger of societies, each retains its individuality. The U.E.S. enables the Founder Societies to coöperate conveniently.

"The Engineering Foundation is a fund of $200,000 belonging to the U.E.S., established for engineering research with a gift from Ambrose Swasey; this fund it is hoped will soon be increased many times.

"The great Library now includes that of the Civil Engineers and contains approximately 75,000 bound volumes and 50,000 unbound volumes. It is believed to be the largest engineering collection in the world. Plans have been made for the development of the Library which contemplate the expenditure of $50,000 annually. At present the societies can only afford to spend $20,000 per year. The Library has an endowment of $100,000. This we hope may soon amount to one million dollars, as the Library needs the income from that sum.

"The United Engineering Society has been established thirteen years. It was originally developed through the efforts of the Societies of Mining, Mechanical and Electrical Engineers. To this organization the American Society of Civil Engineers has joined its strength and prestige and takes a leading part.

"Your new home is being rapidly prepared for you and will be ready during the current year. The six months of intimate association and cordial coöperation we have already had with the officers of your society indicates that a move has been taken of great value and importance to engineers.

"Gentlemen, welcome to your own home."

The professional program of the meeting was devoted to the presentation of the annual reports and the reports from several special committees and the election of officers for the ensuing year. The new officers are: George H. Pegram, president; Alfred Craven, George W. Kittredge, Palmer C. Ricketts and George S. Webster, vice-presidents; George W. Tillson, treasurer, and Charles Warren Hunt, secretary.

Among the reports was that of the Special Committee to Formulate Principles and Methods for the Valuation of Railroad Property and other Public Utilities. This report is the result of five years' work on the part of a committee of nine, who have held forty-eight joint meetings, many of them consisting of three sessions, and who have carried on a voluminous correspondence, aggregating thirteen substantial volumes. This report is of particular interest to our own membership, coming out, as it does, so soon after our own discussion at the Annual Meeting of this important subject. Those of our members who are particularly interested will find this report very helpful in clarifying this subject.

The entertainment part of the program included an inspection of the new Broadway subway in New York City, a visit to Hell Gate Bridge, and an excursion on the East and Hudson Rivers.

THE PRESS ON THE ANNUAL MEETING

THE Annual Meeting of the Society and the papers and discussions were reported by the daily as well as the technical press, some editions assigning prominent positions and considerable space. We believe that the increased attention given by the press reflects in a direct way the increasing importance of the engineer in the affairs of the State, economic as well as industrial. As to the general result of the Annual Meeting, *The Iron Trade Review* says, "In attendance, enthusiasm and general merit of the papers, the meeting surpassed those of past years," with which we are sure our members will be in entire agreement from their personal experience, for this was without doubt the most successful meeting we ever held. In saying this, we must not overlook, however, that there are several factors which contributed to this result, one of which undoubtedly is that to a certain extent these are abnormal times. The European war has acted as a stimulant on our thoughts and energies, we are living in a time of intensified activity, expectant of the future and alert as to what it may bring us. Apart from preparedness campaigns, the reflex action of the war on our national life has been the cause of many economic and industrial developments, some of them taxing the ingenuity of the engineer to his uttermost capacity.

The Chattanooga *News* in its report of the meeting says, "Many people maintain that a great moral and spiritual revolution is now in progress which will change all the thoughts and actions of the world." Although this statement may be somewhat too sweeping, yet it contains some truth. Our outlook and our thoughts are undoubtedly undergoing a change, though we may not even know in what direction, but we are

in a very receptive state of mind at present, which engineers should hail as a splendid opportunity for the initiation and execution of improvements tending to our national advancement; and we believe engineers can be relied upon to do their share in this direction.

In their reports of the meeting, a number of journals and newspapers laid stress on the fact that the field of activity of the engineer is constantly broadening and that he is increasing his influence in all directions. If this means that wherever the engineer steps in, the work will be done more scientifically and more systematically than has been the custom, then this extension of his activity must certainly be welcomed as conducive to the good of the Nation as a whole and should be encouraged in every respect. We believe that the engineering profession will not commit itself light-heartedly to additional responsibilities, but, having accepted them, will not be found wanting. Our Society has always fostered that sense of responsibility in its members which is essential to success. These points are well summarized in *The Iron Trade Review*, which says in this connection; "That the engineer's influence is bound to extend far beyond the conventional limits of the profession was emphasized in the sessions of the 37th Annual Meeting of the Am.Soc.M.E. Scientific management, industrial valuation, safety regulations for cranes and boilers—all subjects outside the old recognized limits of mechanical engineering, claimed most of the attention of the 1500 members and guests of the Society in attendance. The feeling that the engineering profession must take up a large proportion of the burden of national affairs was expressed by several different speakers and the evidence that engineers are eager to assume this added responsibility was furnished by the unusual interest displayed in the subjects of general application." We believe that this accurately expresses the consensus of opinion of the meeting.

Not only is the activity of the engineer extending in all directions, but also the range of subjects before the Society shows a broadening out and extension into the multitudinous ramifications of subjects hitherto somewhat foreign to the engineer. The press took general note of this, *The Iron Age* saying in this connection: "The efficiency of the manager, more about the human factor in industries, the need of a means of collating machine-shop information for the common good, and the undeveloped but necessary place of the mechanical engineer in industrial preparedness were conspicuous topics in the discussions." Thus the engineer not only does things but he endeavors to go to the bottom and find out how to do them best, which in a broader sense means that he is more and more departing from the individualistic standpoint and is learning to view things more from a sociological or national standpoint, even though he would seemingly depart from his customary field of action. "The surprising thing," says the Chattanooga *News*, "was the emphasis placed in many of the papers upon the moral and social aspect." This is a frank recognition of the fact that in the mind of the engineer the financial aspect is giving place to more altruistic ideals. This displacement of finance from supremacy, it will be remembered, was very tersely expressed by Mr. Gantt in his paper when he substituted the "ability to do things" for the "ability to buy things," making the financier give place to the engineer.

With regards to comments on papers before the meeting, the address of Dr. D. S. Jacobus, our retiring president, on Education in Engineering, was very generally quoted and commented on, the recommendations in it receiving unqualified endorsement.

Professor Cathcart's paper on the Development of our Fleet and Naval Stations attracted wide attention. This paper was very prominently announced by such captions as "More Naval Bases Urged," "Charleston Recommended as a Naval Base," "Naval Stations are Inadequate," "Speakers Deplore Lack of Adequate U. S. Naval Stations," "Woeful Unpreparedness on U. S. Coast Depicted," "U. S. Navy far below par in Stations and Destroyers," "South's Lack of Stations is Discussed," "Lack of Bases puts Navy in Peril," "Cathcart's Warning sent to Congressmen;" one of the papers pointing out that it was the best paper produced on the subject in recent years and would certainly receive the attention of the Government. Professor Cathcart's paper is published in this issue of The Journal.

Extensive quotations also appeared from the other papers; there was not a single paper which did not arouse interest in some quarters, though it is also fair to say that some of the papers have not received so far the attention which they merit and it is to be hoped that in due course the technical press will also do justice to these.

PRESIDENT HOLLIS SPEAKS AT CLEVELAND

On January 2, Dr. Ira N. Hollis, President of the Am.Soc.M.E., addressed the Cleveland Chamber of Commerce on the subject of Efficiency and Democracy, in which he advocated, instead of military conscription so prominent before the public in connection with preparedness, a conscription of the whole youthful population to form an army "enlisted against nature." Such an army would, for instance, supply the labor for building the Lincoln Highway across the continent, etc., and there are a thousand other great utilities it might carry out. Dr. Hollis said in part:

EFFICIENCY AND DEMOCRACY

I can hardly claim to bring you a message from New England, as I come from the same side of the Alleghenies as you. My earliest association were with the soldiers of the Civil War and the memories of that time would lead me naturally to avoid war, yet, it is difficult to talk on any subject in America today without some mention of the greatest event in history, made doubly horrible by science and modern invention. We and the whole world are involved and we cannot escape from its consequences.

The great question before the world today is the relation of government to the individual and the attitude of the individual towards his own government. Many of us believe that the whole future of democracy is at stake and that unless democracy can develop as high a national efficiency as autocracy, it is doomed. That is fundamentally the question before the United States today.

What is efficiency? It has expanded as it has become more important in the past few years, and is now applied to nations as a whole. When we take the Century Dictionary definition, namely, "a quality or power of producing desired or intended effects," it is applicable to nations as well as individuals. Another definition is "the state of being able or competent, the state of possessing or having acquired knowledge or skill in any act or profession." In the technical sense the word has a mathematical significance: it is the ratio of useful work to the total energy expended in producing it. This is perhaps the best definition, for it calls attention to the essential of efficiency, the saving of waste in energy and materials. When one stops to investigate our criminal waste of food, our lavish expenditure of time and money on useless things, and our failure to fit transportation into

the distribution of the commonest necessities for great cities, one would almost condemn us as the most inefficient nation on earth.

A few years ago Mr. Frederick W. Taylor undertook investigations to determine with accuracy the best system for workmen as well as for tools. The results ultimately grew into "scientific management," so called by Louis Brandeis, in order to direct the mind effectually to the essentials of the method: viz., getting the maximum return in manufacture for a given expenditure of time, money and effort, by the scientific planning and allotment of tasks to every tool and employee. Under Mr. Taylor's development of the subject we have always the idea of the manufactured product, but the term is capable of a much larger application in relation to communities or nations as a whole. The true meaning of efficiency, in a larger sense, is the regulation of one's life so that society shall receive the maximum return in service and in happiness.

The application of the word efficiency to our government is better brought out in connection with the real meaning of the term democracy. Abraham Lincoln defined it for all time in the words "government of the people, by the people, and for the people." It makes no difference what the head of the State may be called, so long as his definition holds. Presidents and kings alike, are equally powerful, or equally powerless, when the rules are made by the people themselves. After all, there are only two forms of government, one by the few, aristocracy, and the other by the many, democracy.

In discussing the comparative merits of the two governments democracy, as illustrated by the United States, and aristocracy, as illustrated by Germany, Americans are not always judicial. They are either unduly confident or over-sceptical as to the future of our form of government.

Is it true that efficiency is best developed under democracy and that in the long run a nation is stronger against war with the individual initiative there taught than it could be under an autocracy? Any American would naturally say yes, in the belief that men do better what they consent and wish to do, than when they act under compulsion. But we should be utterly mistaken if we judged the German nation by that measure. In contrasting Germany with the United States we have been too quick to take it for granted that German citizens were acting under the compulsion of a military caste. If so, they have been able to hide the evidence of compulsion, because they have freely consented to conscription during the vast military organization under which their people have been prepared for war, and under which their advance in a material way has been beyond the power of the imagination.

Our own country was a very interesting example of the two types of government during the early years of the Civil War. The Southern Confederacy was practically an aristocracy, with a slaveholding class who took all the offices, and a great population of whites and slaves accustomed to guidance by a governing class. At the outset of the Civil War they were more efficient than the North. It took the North a long time to organize, and it was not until after Vicksburg and Gettysburg that the Southern cause began to wane. The Northern armies had gradually been worn down into effectiveness and the administration had gone into the West, the most flagrantly democratic part of the country, for its commanding officers. This experience in our long war seems to justify the claim that democracy is strongest in the long run. I am a profound believer in democracy as Lincoln defined it. If stripped of certain ugly excrescences, it is the hope of man.

The Declaration of Independence states that all men are created equal, and that they are endowed by their Creator with certain inalienable rights; that among these are life, liberty, and the pursuit of happiness. We have by constant dwelling on the word "equality" twisted it out of the meaning that our forefathers intended to give it. As a matter of fact, the Declaration of Independence was the statement of a noble reaction against bondage in a feudal system, and it expresses fundamentally that men should be equal as to opportunity. It could never determine the equality of men as to physical and mental endowments. They are distinctly not equal and never have been, and no fiat can ever make them so. Nature has taken care of that. In our democracy, we should dwell on the equality of opportunity to serve.

On the court house in Worcester is this sentence, "Obedience to Law is Liberty." That obedience to law is a necessary element of true liberty has been the doctrine of philosophers since the dawn of recorded history. We cannot deny it and we know that our country's liberty is less for every violation or disregard of law.

The finest definition of a man's place in our democracy is found in the statement that here he will be permitted to develop himself to his maximum possibility in the service of mankind. Observe the word "permitted" to develop one's self. It signifies that the individual must learn how to use this permission before it becomes really of value to him.

How far must the efficiency of the individual give way to the collective efficiency of a large number of individuals, or of the state? An engineer will understand the force of this question, because he is in the habit of effecting compromises in the selection of machinery for manufacturing or power purposes. In steamships, for instance, it is a well-known principle that a screw propeller generates its highest efficiency at a comparatively low speed of rotation, while a steam turbine is quite the opposite in reaching its higher efficiency at a very high rate of speed. When they are coupled together for propulsion, both must surrender something in order that their combined effort may produce the maximum result.

In the same way, every individual of every community should consider his conduct and his work as affecting all others with whom he is associated, and all others who live under the same flag. If his efficiency in business becomes so distorted that it interferes with the rights and the happiness of others, it must be curbed and checked so that the maximum of service and happiness will be found for all.

The chief danger to any democracy grows out of a false standard. We know in our hearts that the ideals of this country are clean and sound, and yet we stimulate enterprise and initiative by an appeal to the most selfish side of human nature. The patent laws, the entry of public land, and the rights to property, all good within limits, have produced most of the litigation because they are based on selfishness; and the worst of it is that few can see any other practicable or possible method of holding society together. It is a false standard and there is something better in our love of fair play, our charity to our neighbors, our passion to pay and our desire to serve. If we can only let them sway us in relation to our own government as in private life, the republic will be safe for all time and democracy will win the earth.

We have a very curious and striking illustration of liberty and efficiency in the acts of the trade unions. In the name of liberty they claim the right to organize against capital and then in the name of efficiency of organization, they demand the most slavish obedience from their members. There is no liberty in a trades union. Capital is not free from a similar failure to consider the true good of the state or community. The virtual control of property in the United States is in the hands of comparatively few men who have until lately paid no attention to public interests. There is little to choose between capital and labor in their indifference to the efficiency of the state and to the combined effectiveness of all. Between the two of them the public has small consideration, except to pay.

Has any healthy and mentally sound individual a place in any community to which he renders no service or where he makes no contribution to the welfare of the state? This sounds like harsh puritanism, and yet it is not when you stop to think about it. There is in machinery a quality known as hunting. It is found in the steam engine when the governor has a high initial resistance. If the speed increases and the governor does not act, the engine will run away until the governor does act; then it will act too much and carry the engine to the other extreme. This bad quality may be improved, but hunting is always present even in the turbines that supply your power and light. The engine is all the time hunting the average normal speed without ever finding it. In many respects humanity is like that, always striving and never attaining.

If I accomplish nothing else than to call your attention to an essay by William James, on the Moral Equivalent of War, I shall be satisfied with my visit to Cleveland. He has given us one of the noblest conceptions of man's future, and best of all the way out of blood and crime. In the first paragraph of his essay he says: "The military feelings are too deeply grounded to abdicate their place among our ideals until better substitutes are offered than the glory and shame that come to nations as well as to individuals from the ups and downs of politics and the vicissitudes of trade. There is something highly paradoxical in the modern man's relation to war. Ask all our millions, north and south, whether they would vote now (were such a thing possible) to have our war for the Union expunged from history, and the record

of a peaceful transition to the present time substituted for that of its marches and battles, and probably hardly a handful of eccentrics would say yes. Those ancestors, those efforts, those memories and legends, are the most ideal part of what we now own together, a sacred spiritual possession worth more than all the blood poured out. Yet ask those same people whether they would be willing in cold blood to start another civil war now to gain another similar possession, and not one man or woman would vote for the proposition."

What relation has this to the state of mind of the American people? We have had no end of discussion about national defense, the Army and Navy, and universal military service. War is clearly in the air and any one of several questions might bring it like a thunder clap. Not one man or woman would vote for it, but we are in the hands of fate. Will it be possible for any nation to remain neutral in the next war, or in this, if it lasts out another summer? I am a believer in thorough preparedness immediately, and yet I am persuaded that we have taken the public mind away from what should be the great ideal of our republic by emphasizing the word "military" at the expense of the word "service." It is service in every direction that is needed, and no young man can discharge his obligation to the state by a few months in camp. The whole matter hinges on a state of mind. Of course military training may form part of any collective training for the service of the country, but it is not the chief one.

Perhaps the settled idea of all this writing is found in the last sentence of the following paragraph: "The martial type of character can be bred without war. Strenuous honor and disinterestedness abound elsewhere. Priests and medical men are in a fashion educated to it, and we should all feel some degree of it imperative if we were conscious of our work as an obligatory service to the state." After all, it is Service that Mr. James is putting forward as the only antidote to decadence.

How can efficiency be promoted in a democracy? We must again keep in our minds the fact that there are two efficiencies: one, the efficiency of the individual; the other, the efficiency of the collective mass. Our efficiency as a whole will maintain the republic, but the efficiency of the individual acting alone will create such division as to destroy it. That of the individual is soundly promoted by complete freedom of speech, complete freedom of choice as to a career, and by a preservation of the ideals of service as distinguished from sense enjoyment. We have the first two of these eminently developed in the United States, but the last has been clouded over. We have leaned too much on literature and art as representing the higher things, in comparison with the utilities of life. As a matter of fact, neither one of them is worthy of consideration if carried to a debauch, and there is something far higher and more ennobling than either. We do not fix our high moral purpose by reading some beautiful piece of literature or looking at some great picture or by making a lot of money on some invention, but we get it by the experience of life, if that experience takes the proper perspective. It is Christ's conception of life and service that will give us efficiency as individuals in dealing with others. We are too easily misled by college professors into the belief that critical study forms the broadening and enlarging developer of man's soul and mind. Colleges have been comparatively inefficient in turning the mind towards that kind of universal service that will create in this country a united nation. The popular idea that colleges are failures in respect to public service is exaggerated, and yet one cannot but feel that they have achieved far less than might have been hoped from their claims of breadth and education.

As to the efficiency of the collective mass, my belief is that Professor James has suggested the best solution possible in the words: "If now there were, instead of military conscription, a conscription of the whole youthful population to form for a certain number of years a part of the army enlisted against nature, injustice would tend to be evened out and numerous other goods to the commonwealth would follow." It is not necessary here to suggest the elements of the warfare against nature; one of them, however, comes readily to mind. Suppose, instead of an appropriation of millions by the government of the United States and by the states to build the great Lincoln Highway across the continent, that the work on this highway were a free gift of our young men, under universal service, we should then have an enduring monument to love of country and an ennobling incentive to the right kind of patriotism. That great artery of commerce and recreation would hold memories of splendid achievement for generations to come and it would always bind the states far better than interstate laws.

The Lincoln Highway is only one of many things that can be offered by the youth of the country. There might be a Washington Highway from Maine to Texas passing through the mountains of Kentucky and Tennessee. The mind can suggest a thousand other great utilities. It has been claimed that service under the flag in Germany and France has served to educate the people. That is a pure preparation for war which has been going on during the past fifty years as the means of educating the masses. I do not believe for one instant that it offers half the stimulus that constructive service in peace would bring to our youth. All the discipline of the army can be found in the working party with the pick and shovel taking the place of the rifle.

The Army never will be in a satisfactory condition until we get rid of the dual control involved in the state-militia idea and substitute for it a citizen soldiery with only a nucleus of men permanently under arms. This involves of course the Swiss system or the Australian system of universal training, beginning in the public school and continuing for 10 or 15 years.

The appropriations are only stop gaps, however, and we must provide a lasting remedy for the loose, flabby ideas of service held by too many voters. Our main task is only begun, that of arousing a national spirit by every means in our power. Industrial preparedness is only a small part of it. Coöperation in everything is demanded, in education, in religion, in the industries and in citizenship, for the purpose of fusing this conglomerate population into a united, efficient and peaceful nation, capable of serving and advancing civilization. Let us do our share.

Junior and Student Prizes

The attention of Junior Members of the Am.Soc.M.E. and of members of its Student Branches is called to the prizes offered each year by the Society for the best paper by a Junior Member and for the two best papers by enrolled members of Student Branches. The former of these prizes is a cash prize of fifty dollars and engraved certificate, and the latter are cash prizes of twenty-five dollars each and engraved certificate.

The rules covering the award of these prizes are given in the Year Book of the Society, the 1917 Edition of which is about to be issued. The last date for submitting papers for consideration by the Committee on Awards this year is June 30, 1917.

Those who intend to participate in this competition should make their plans now so that their papers will be ready in ample time. They should select a subject of practical value and treat it in a simple, correct, clear and forcible manner. A subject might well be a description of a new mechanical invention or piece of engineering apparatus; an account of some original work in the laboratory, shop or classroom; a description of a new and novel piece of mechanical construction; a description of a novel modification to an existing plant; an explanation of plans or methods of proposed engineering work; a summary of present practice in a given mechanical field, or an argument for or against a particular mechanical apparatus, process, construction, etc.

The Secretary will be glad to furnish any information or to give any suggestions to those intending to compete for either of these prizes.

Correction

Mr. R. J. S. Pigott reports that the statement on page 1009 of the December issue that his "later work included the preliminary design and layout of the extension to the Seventy-Fourth Street Station" is incorrect. His work included not only the layout but also the actual construction and testing of this extension.

CANDIDATES FOR MEMBERSHIP

TO BE VOTED ON AFTER MARCH 10, 1917

THE American Society of Mechanical Engineers is an organization for mutual service of over 7700 engineers and associates coöperating with engineers. The membership of the Society comprises Honorary Members, Members, Associates, Associate-Members and Juniors, all elected by ballot of the Council. Application for membership is made on a regular form furnished by the Secretary which provides for a statement of the standing and professional experience of the applicant and requires references from voting members personally acquainted with the applicant. The requirements for admission to the various grades will be furnished upon request.

Below is the list of candidates who have filed applications for membership since the date of the last issue of The Journal. These are classified according to the grades for which their ages qualify them, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third class under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to scrutinize this list with care and advise the Secretary promptly of any objections to the candidates posted. All correspondence in this regard is strictly confidential. Unless objection is made to any of the candidates by March 10, 1917, and providing satisfactory replies have been received from the required number of references, they will be balloted upon by the Council. Those elected will be notified about April 15, 1917.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Arizona

LANDRY, CALISTE F. A., Mechanical Engineer, Power Plant, Inspiration Cons. Copper Co., Globe

California

BANE, THURMAN H., 1st Lieutenant of Cavalry, U. S. Army, Aviation School, San Diego

Connecticut

EALES, WILLIAM P., Asst. Supt., Engineering and Inspection Div., Travelers Insurance Co., Hartford

District of Columbia

BROOKE, LLOYD A., Designing Draftsman, Ordnance Dpartment, U. S. Naval Gun Factory, Washington

Illinois

CARLSON, ADOLPH G., Chief Engineer, Universal Portland Cement Co., Chicago

HOWIND, H. ERNST, Checker, Mechanical Engineering Office, Illinois Central R. R. Co., Chicago

LINK, MAXIMILIAN W., Assistant Mechanical Expert, Crane Co., Chicago

NELSON, S. T., Superintendent, Chicago Plant, Sullivan Machinery Co., Chicago

PITTSFORD, WILLIAM A., Kewanee Boiler Co., Chicago

WILSON, JOSEPH B., Sales Department Engineer, Westinghouse Elec. & Mfg. Co., Chicago

Massachusetts

ANGIER, EDWARD H., President and Treasurer, Angier Mills, Ashland

ADAMS, COMFORT A., Professor of Electrical Engineering, Harvard University, Cambridge

BROWN, EDWARD C., Plant Engineer, Industrial Service & Equipment Co., Boston

CABOT, WALTER K., Assistant Manager and Mechanical Engineer, William Underwood Co., Boston

PUTNAM, ARTHUR D., Civil and Mechanical Engineer, Worcester Electric Light Co., Worcester

Minnesota

MILLER, STANLEY G., Vice-President, Crex Carpet Co., St. Paul

New Jersey

DAVIES, THOMAS H., Engineer in Charge, W. L. Dickinson High School, Jersey City

KAVANAGH, THOMAS J., General Superintendent, American Sugar Refining Co., Jersey City

MORGAN, JOHN D., Engineer, Inventory and Appraisal Dept., Public Service-Elec. Co., Newark

PICKEL, HARRY A., Superintendent of Power, Hercules Powder Co., Kenvil

New York

ABA, EUGENE, Tool Designer, Pierce Arrow Motor Car Co., Buffalo

ALLEN, JARED E., Superintendent Engineering Department, Oneida Community, Ltd., Oneida

ANTHONY, JAMES T., Assistant to President, American Arch Co., New York

BOWLES, HARDY, Civil Engineer, Eastern Terminal Div., The Texas Co., New York

CLOCK, ERNEST E., Chief Inspector, Engrg. and Fly Wheel Dept., Fidelity & Casualty Co., New York

COOKSON, ALFRED W., Maintenance Engineer, Morrow Mfg. Co., Elmira

RICHARDSON, FRANCIS J., Heating and Ventilating Inspector, Board of Education, New York

RIPLEY, CHARLES M., General Electric Co., Schenectady

Ohio

GROTHE, WALTER, Mchanical Engineer, National Carbon Co., Fremont

MONAHAN, WILLIAM H., JR., Chief Draftsman and Supt. of Cons., Whitaker-Glessner Co., Portsmouth

MOSHER, CLIFFORD C., General Manager, East Iron & Machinery Co., Lima

Pennsylvania

BOCKIUS, STEHMAN A., Sales and Contracting Engineer, S. A. Bockius Co., Pittsburgh

KERSTING, ALBERT H., Charge of Ordnance Inspection Dept., Bethlehem Steel Co., So. Bethlehem

PANCOAST, ALBERT, Vice-President and General Manager, Union Spring & Mfg. Co., New Kensington

WERA, EUGENE L. J., Draftsman, Westinghouse Machine Co., E. Pittsburgh

England

THORNTON, HENRY W., General Manager, Great Eastern Rwy., London, E. C.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

California

MASSER, HARRY L., Head Draftsman, Southern California Gas Co., Los Angeles

SOMERVILLE, GEORGE N., Chief Draftsman, Skandia Pacific Oil Engine Co., Oakland

Connecticut

ADAMS, LYMAN D., Manager Mill Dept., The Wallace Barnes Co., Bristol

Delaware

HOOPES, EDGAR M., Chief Engineer, Board of Water Commissioners, Wilmington

Indiana

BURRESS, LOYD F., Superintendent Coke Ovens, Illinois Steel Co., Gary

HEIGN, HARRY B., Engineer, Indiana Public Service Commission, Indianapolis

Louisiana

DURR, GEORGE E., Engineer, General Fire Extinguisher Co., New Orleans

Massachusetts

ROBBINS, WALTER C., Chief Checker of Designs, New England Westinghouse Co., Chicopee Falls

WILLIAMS, SILAS, Engineer, New England Westinghouse Co., Springfield

Michigan

SHOEMAKER, SAMUEL S., Technical Assistant to Superintendent, Semet-Solvay Co., Detroit

Minnesota

CALL, ALMON E., Assistant Engineer of Tests, Island Creek Coal Sales Co., Minneapolis

HUBBELL, ARTHUR C., Machine Designer, C. D. Enochs, Cons. Engr., Minneapolis

Missouri

GAUSS, HENRY F., Assistant Mechanical Engineer, Operating Section, Water Div., Dept. of Public Utilities, St. Louis

Nebraska

KYHL, LOUIS C., Charge Drafting Office, American Smelting & Refining Co., Omaha

New Jersey

ALLEN, ABBOTT, Engineer, E. H. Mumford Co., Elizabeth

New York

APPELQUEST, JEROME A., Engineer in Charge, Syracuse Office, Ford, Buck & Sheldon, Inc., Syracuse

BLANCHARD, EDWARD J., Assistant Engineer, R. Martens & Co., Inc., New York

BOND, WILLIAM L., Time Studies and Investigations, Remington Typewriter Works, Ilion

MOFFITT, FRANCIS A., Senior Partner, B. O. Moffitt's Sons, Binghamton

Pennsylvania

JOHANNSEN, JOHN F., Chief Tool Designer, Remington Arms Co., Eddystone

ROBERTSON, ARTHUR R., Erecting Engineer, Westinghouse Machine Co., E. Pittsburgh

RYAN, FREDERICK J., Manager of Eastern Office, Snyder Electric Furnace Co. of Chicago, Philadelphia

STRUBLE, GEORGE W., General Superintendent Redington Plants, Bethlehem Steel Co., So. Bethlehem

WADSWORTH, JOHN F., Associate, Richard Irvin & Co., Erie

Wisconsin

SCHERNER, JOHN, Mechanical Engineer, The Federal Rubber Co., Cudahy

India

ABRAHAM, KODIATE J., Chief Engineer and General Manager, The Eastern Rubber Mfg. Co., Tiruvalla, Travancore

FOR CONSIDERATION AS JUNIOR

California

BARNHART, GEORGE E., Chief Tester, Aviation Motors, Signal Corps Aviation School, San Diego

Connecticut

COOPER, WILLIAM K., Efficiency Engineer, Winchester Repeating Arms Co., New Haven

SANFORD, NEWTON W., Overseer Production and Inspection, Drafting Room, Winchester Repeating Arms Co., New Haven

STIMMEL, VIRGIL B., Mechanical Draftsman, S. K. F. Ball Bearing Co., Hartford

Louisiana

MOSES, WALTER B., Sales Engineer, A. M. Lockett & Co., Ltd., New Orleans

Maryland

GAIL, GEORGE W., Engineering Department, Bethlehem Steel Co., Sparrows' Point

LYON, HOWARD B., Instructor in Marine Engineering, U. S. Naval Academy, Annapolis

Massachusetts

GUTHRIE, JOHN F., Mechancial Engineer, Arnold Print Works, North Adams

Michigan

ASHMUN, LOUIS H., Engineering Draftsman, Dow Chemical Co., Midland

HARRIS, RAYMOND B., Combustion Engineer, Detroit Edison Co., Detroit

STEWART, EARLE H., Instructor, Michigan Agricultural College, East Lansing

Minnesota

SMITH, J. EDGAR, Locomotive Designer, Great Northern Railway Co., St. Paul

New Jersey

HORTON, MARSHAL G., Cadet Engineer, Public Service Elec. Co., Newark

New York

KEENE, ALBERT R., Draftsman, Doehler Die Casting Co., Brooklyn

LORENZI, OTTO, Engineering Department, Combustion Engineering Corp., New York

WILLIAMS, SAMUEL C., Export Department, J. P. Morgan & Co., New York

WUNSCH, JOSEPH W., Mechanical Engineer, Hanau Engineering Co., New York

Ohio

GIBBS, CHARLES W., Student, The Babcock & Wilcox Co., Barberton

GUEST, W. E., Efficiency Engineer, The American Tool Works Co., Cincinnati

OSTER, EUGENE A., Mechanical Engineer, Ault & Wiborg Co., Cincinnati

PHILLIPS, VICTOR B., Engrg. Asst. to Superintendent of Power, The Cleveland Rwy. Co., Cleveland

Pennsylvania

FLANAGAN, WALTER N., Superintendent, National Brush Washing Machine Co., Pittsburgh

KLOPP, CHARLES G., The Pittsburgh Crucible Co., Midland

SPIETH, BENJAMIN S., Apprentice, Westinghouse Mch. Co., Pittsburgh

WINTERLING, CLEE C., Engineer Steam Engineering Department, Cambria Steel Co., Johnstown

Rhode Island

DUNBAR, ROBERT H., Mechanical and Hydraulic Engineer, Providence Engineering Works, Providence

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE MEMBER

Massachusetts

COVE, JAMES R., Master Mechanic, Massachusetts Cotton Mills, Lowell

Ohio

BIDDISON, PASCAL, Construction Engineer, Ohio Fuel Supply Co., Columbus

PROMOTION FROM JUNIOR

Connecticut

LINDQUIST, E. A., Superintendent, W. & B. Douglas, Middletown

Georgia

NOTT, ALBIN J., Mechanical Engineer, Central Georgia Power Co., Macon

Oklahoma

HACKSTAFF, JOHN D., General Manager, Empire Pipeline Co., Bartlesville

Missouri

AZBE, VICTOR J., Member, Engineering Department, Anheuser Busch Brew. Assn., St. Louis

New York

GILSON, HARRY W., Secretary-Treasurer, Vincent-Gilson Engrg. Co., New York

STEWART, CHARLES A., Engineer, Steel & Ordnance Corp., New York

SUMMARY

New Applications	88
Applications for change of grading:	
Promotion from Associate-Member	2
Promotion from Junior	6
Total	96

NECROLOGY

HENRY G. STOTT

Henry Gordon Stott, superintendent of motive power of the Interborough Rapid Transit Company and New York Railways Company of New York, died at his home in New Rochelle, January 15, 1917, after an illness of many months.

He was a native of the Orkney Islands, Scotland, where he was born in 1866. After a thorough grounding in the fundamentals at the hands of his father and elementary school instructors, he was enrolled as a student at the Watson Collegiate School, Edinburgh. On leaving this institution he entered the College of Arts and Sciences at Glasgow, and began a course in mechanical engineering and electricity, graduating in 1885. In the year previous he had entered the employ of the Electric Illuminating Company of Glasgow. Shortly after graduating he was made assistant electrician on board the steamship *Minia,* belonging to the Anglo-American Telegraph Company. For the next four and one-half years he was engaged with those duties, during the course of which he saw much service in connection with repairs to the cable lines of that company. In this period he undertook a number of experiments that resulted in the introduction of improved methods of handling cable repairs. He was also identified with the "duplexing" of the United States Cable Company's main cable (2750 knots), the longest duplex cable in the world.

HENRY G. STOTT

In 1889 Mr. Stott was made assistant engineer of the Brush Electric Engineering Company's plant at Bournemouth, England. The following year he was offered a post by Hammond & Co. as assistant engineer in the construction of an underground cable and power plant at Madrid, Spain. He remained there until 1891, when he came to the United States to install an underground cable and conduit system for the Buffalo Light and Power Company (now the Buffalo General Electric Company). This work was completed with a degree of success that reflected very greatly to the credit of Mr. Stott, and as a result he was named engineer of the company, and during the next ten years was one of the most active figures in the industrial progress of Buffalo. During this period he designed and executed some notable construction work, including a power plant on Wilkeson Street, Buffalo.

His work attracted wide attention and in 1901 he was appointed superintendent of motive power of the Interborough Rapid Transit Company, New York City, a position which he filled with signal success. At the time he took up these duties the Interborough had not yet been organized, the company having the title of the Manhattan Railway Company. The post which Mr. Stott was called to had just been created, and it devolved upon him to organize the operating force, in connection with which he completed the Seventy-fourth Street power plant of the company, various sub-stations and transmission lines.

When the Manhattan system was amalgamated with the Interborough, in 1904, Mr. Stott was invited to retain his office with the new corporation. He accepted and immediately took over supervision of the construction of the power plant on Fifty-ninth Street. Since that time he has been constantly in charge of design, construction and operation of the power-generating stations and the distributing system of the Interborough, which comprehends both the subway, elevated and surface lines of New York City.

The plans for the electric-power system of the new subway lines have been developed under his supervision and the construction has progressed so far and bears so strongly the stamp of his work that when completed it will be a monument to him.

Mr. Stott was a firm believer in coöperation among engineers through the agency of the engineering societies. He was elected president of the American Institute of Electrical Engineers for the term of 1907 to 1908. He was a manager of The American Society of Mechanical Engineers from 1907 to 1910, and from 1911 to 1912, and he was vice-president of the Society from 1912 to 1914. He was a director of the American Society of Civil Engineers in 1911, and was vice-president and a trustee of the United Engineering Society at the time of his death.

In the American Institute of Electrical Engineers he was a member of the Standards Committees, the Public Policy Committee, the Committee on Development of Water Power, the United States National Committee of the International Electrotechnical Commission, the Power Stations Committee, the Committee on Economics of Electric Service and the Edison Medal Committee. He was one of the Institute representatives on the Joint Committee on the Metric System, of which he was an ardent advocate.

In the Mechanical Engineers, he served on the Special Committee on Pipe Thread Gages in 1913 and 1914, as chairman of the Committee on Flanges and Pipe Fittings from 1912 to 1914, as chairman of the Conference Committee on Electrical Engineering Standards in 1913 and 1914. He was a member of the Executive Committee of the Council in 1913 and 1914, a member of the Advisory Committee of the Boiler Code Committee, and in 1916 was appointed a member of the Standardization Committee. He represented the Society on the Board of Trustees of the United Engineering Society.

As a result of his unusually wide experience and extended research, Mr. Stott was called upon often to contribute papers to the various engineering societies. He was especially well known for his minute analysis of engineering problems. Among the large number of papers which he has written on his subjects are The Conversion and Distribution of Received Currents, Power Plant Economics, Notes on the Cost of Power, Steam Pipe Covering and Its Relation to Station Economy, Tests of a 15,000 Kilowatt Steam Engine Turbine Unit, Power Plant Design and Operation (a series), etc.

Mr. Stott was a remarkable figure in the engineering world because he was in the front rank of both electrical and mechanical engineers; because in both branches of the art he was a master of theory and practice, and because with these technical qualifications he combined a rare executive ability and power of inspiring the confidence of his employees and of bringing out the best that was in the men who worked for him.

W. S. F.

AUGUSTUS W. COLWELL

Augustus W. Colwell, who died in New York on January 2, 1917, was a member of one of the oldest families of mechanics in New York, a pioneer in the manufacture of sugar machinery of the modern type, and a man who was associated in many ways in the engineering development of the country during the past fifty years. He was the oldest son of Lewis Colwell, founder of the Colwell Iron Works, who started in business for himself in 1840 in a small foundry on Charles Street, New York. Among the important undertakings of the Colwell Iron Works was the establishment as an adjunct of the main business a ship building yard in Jersey City, where several of the Civil War monitors were constructed and many vessels of the United States Navy were prepared.

Mr. Colwell was born in New York City on February 5, 1842, and educated in the public schools and in the College of the City of New York. In 1861 he was apprenticed in his father's machine shop and foundry, starting in the drawing room and later working in the foundry as a moulder. He afterwards was general superintendent of the plant and spent portions of each winter in Cuba inspecting the erection of the company's sugar machinery and attending to new orders. On the death of his father he purchased the interests of the other heirs and became president and owner of the Colwell Iron Works, until 1906, when he retired from business. By his numerous inventions and by leading in advanced engineering and foundry practice, he became prominent in English, French and Spanish-speaking America as a manufacturer of sugar machinery, and apparatus for the manufacture of other products requiring the use of evaporators, as well as steam engines, pumping engines, and miscellaneous machinery.

Under his supervision the first successful diffusion battery for handling sugar cane liquors was erected and operated at the Louisiana Experimental Station located on Governor Warmoth's Magnolia Plantation on the Lower Coast. He was among the first to design and manufacture machinery to use bone char for refining sugar and used it at the plantation for refining direct in one process. He was a pioneer in the use of water tube boilers on sugar plantations in which bagasse was used as fuel. He patented a bagasse burner for this purpose and installed plants using this fuel on plantations in Cuba. His system of returning all exhausts and drips to the boiler house and utilizing the exhaust steam for the vacuum pan and triple effect was much sought for by the planters.

He also was one of the first engineers to advocate clarifiers, steam trains and centrifugals to take the place of the old open kettle direct-fired as used by the earlier sugar makers. He remodeled many old style plants on sugar plantations by supplying centrifugals to eliminate the molasses from the magua after it left the vacuum pan. By contrast, the old cone moulds and banana leaf moulds which were common at that time had to be stored for weeks in dark cellars and allowed to drain in order to eliminate the molasses.

A great deal of interesting work was done by Mr. Colwell in fields totally different from those which engaged his chief attention. He patented and erected for New York City refuse crematories which were used by the late Colonel Waring when he was Commissioner of Street Cleaning. He did the steel and iron work for a number of lighthouses erected on the Atlantic and Gulf coasts. He made many experiments for the United States Government in the interest of the sorghum industry, designing and operating the machinery, and also furnished much machinery for the glucose trade. It is interesting to note that Lewis Colwell, his father, was the first to use coal in a cupola to melt iron, and that similarly he was the first, in New York City, to use coke in a cupola.

During the Civil War, in spite of the fact that the Colwell Iron Works were actively engaged in Government work, Mr. Colwell enlisted twice with the 137th New York Volunteers and was honorably discharged as Color Sergeant. About 1886 he was made Commander for the term of two years of the John A. Dix Post 135 of the Grand Army of the Republic.

Mr. Colwell was one of the charter members of The American Society of Mechanical Engineers and signed the register at the first Annual Meeting. During the past ten years he traveled extensively, once around the world, once to the Orient and once to South America. He is survived by four sons, all following the engineering profession, and by a daughter.

ALFRED C. EINSTEIN

Alfred C. Einstein was born in Hoboken, N. J., in 1866. He received his elementary education in the St. Louis Public Schools, later graduating from the Manual Training School. He began a course in Washington University, but left before its completion, to become manager of a mining property in Silver City, N. M., which position he held for several years.

In 1891, Mr. Einstein returned to St. Louis to become president of the Consolidated Engineering Co., and held this office until 1894. During that period he succeeded in building forty different plants, including waterworks, steam plants and electric- and street-railway plants.

Between the years 1894 and 1896, he was vice-president and manager of the Paducah Electric Light and Street Railway Co., of Paducah, Ky. He sold out his interest in this company in 1896 and returned to St. Louis, where he purchased the Suburban Electric Light and Power Co. He also organized the St. Louis County Gas Co.

In 1904, he sold the Suburban Electric Light & Power Co. to the North America Co., and in 1906 purchased the King Electric Light Co., which later was merged with the Suburban Electric Light and Power Co. In 1911 he became vice-president and general manager of the Union Electric Light and Power Co., which office he held at his death, November 20, 1916.

Mr. Einstein had always taken an active interest in the business and civic affairs of St. Louis. He was the fourth vice-president of the Business Men's League, and was largely instrumental in bringing many conventions to St. Louis. He became an Associate-Member of the Society in 1905.

THOMAS HATTERSLEY BELCHER

Thomas Hattersley Belcher was born in Newark, N. J., in December 1876. He was educated in the Newark High School and later in the technical and mechanical drawing schools. His early experience in mechanical work was obtained while in the employ of Cyrus Currier & Sons, Newark, N. J. In 1900 he affiliated with A. & E. Brown Co., as engineer and superintendent of installations of power transmission equipment in manufacturing plants. In 1904 he became assistant chief engineer of that concern. Between 1906 and 1913 he was with the Chicago Coated Board Co. as general mechanical superintendent. In May 1913 he became engineer and representative for the Black-Clawson Co., Hamilton, O., resigning after two years, to become manager of the Carthage Machine Co., of Carthage, N. Y. His death occurred Nov. 7, 1916, while acting in this capacity. He became a Member of the Society in 1913.

FREDERICK W. HOLMGREN

Frederick W. Holmgren was born December 29, 1891, in Brooklyn, and died there December 29, 1916. He received his early education in the Brooklyn Public Schools and attended Manual Training High School for a time. After leaving school, he took an evening course at the Brooklyn Polytechnic Institute, working in the projectile department of the E. W. Bliss Co., Brooklyn, during the day. He received his degree of Mechanical Engineer from that institution in June, 1914. He remained with E. W. Bliss Co. for a time after his graduation, resigning to enter into partnership with the Berggren & Pearson Machine Co. of New York, with which concern he was affiliated at the time of his death. He was elected to Junior Membership in the Society in November, 1915.

NAPOLEON DuBRUL

Napoleon DuBrul was born in Montreal, Canada, on June 22, 1846, and died in Cincinnati, October 23, 1916. At the age of fourteen, he became apprentice in the Gilbert Machine Shop. In 1866 he went to Chicago where he invented the tin cigar mold and later the tin-lined wooden cigar mold. He removed to Cincinnati in 1872 and in 1879 became a member of the firm of Miller, DuBrul & Peters Mfg. Co. In 1893 the members of the firm bought and reorganized the Anniston Pipe and Foundry Co., of Anniston, Ala., which was later consolidated with the American Pipe & Foundry Co. of Chattanooga, Tenn., and in turn was sold to the U. S. Cast Iron Pipe & Foundry Co.

Mr. DuBrul devoted his inventive skill to the development of machinery for making cigar molds. He designed, patented and marketed many different machines and appliances used in the cigar business in all countries of the world.

He became a Member of the Society in 1900 and was a member of the Business Men's Club and the Queen Club of Cincinnati.

WILLIAM L'E. MAHON

William L'E. Mahon was born in Detroit, Mich., June 19, 1861. His education was secured at the University of Michigan, succeeded by a course at the Massachusetts Institute of Technology. He specialized in marine-engine-construction work, beginning as an apprentice in the Dry Dock Engine Works in Detroit, and being later engaged as mechanical engineer and chief draftsman with the Frontier Iron & Brass Works, later acting as assistant superintendent on construction of heavy marine engines with the same works, and subsequently with the Brown Hoisting Machinery Company of Cleveland, O., with which company he continued several years.

Mr. Mahon was also connected several years with the New York office of Taylor Wharton Iron & Steel Company, of High Bridge, N. J., later representing them in the Pacific Northwest. It was while engaged in work with the last-named company, with headquarters at Butte, Montana, that he died, October 6, 1916, at Ogden, Utah.

Mr. Mahon was a member of the Technology Club of New York and became a member of this Society in May, 1889.

AMONG THE SECTIONS

During the month just closed, President Hollis has visited the Sections at Detroit, Chicago, Milwaukee, New Orleans, Birmingham and Atlanta, also the Student Branches at Purdue University and the Georgia School of Technology. In his tour of these Sections and Branches, President Hollis spoke in addition at the Cleveland Chamber of Commerce and the Detroit Chamber of Commerce, and addressed the students at Tulane University. Dr. Hollis' message to these Sections and Branches is published below, embodied in the reports of the meetings which he addressed.

Our two new sections, at Erie and Indianapolis respectively, both report progress in their plans of activities. At Indianapolis an Engineers Club is being organized and this will be an affiliation of the several local engineering organizations, including our own Section. At Erie, the new Section is putting into effect plans for securing a substantial membership. This Section will work in close coöperation with the existing local engineers' society, the Engineers Society of Western Pennsylvania, and a committee consisting of R. F. Benzinger, chairman, H. N. Dodge and F. P. Klund, has been appointed to work out the exact relations between our Section and the local society.

The New Year has brought the Providence Engineering Society a long and varied monthly program. The society is to be congratulated on its endeavor to make this year a banner year for the engineering profession in Rhode Island. No less than five meetings of the society were held in January, at two of which new sections, a Power Section and a Municipal Highway and Water Supply Section, were formed.

SECTION MEETINGS

BALTIMORE, DECEMBER 13

At a meeting of the Baltimore Section on December 13, 1916, a report of the committee handling the organization of the Associated Technical Societies was considered. This association is to consist of eight branches of national societies in Baltimore and other societies duly elected by the Board of Governors. Its purposes are to advance the interests of all technical organizations through coöperation, to promote goodwill and fellowship between the members of the various societies and to present for discussion and action, subjects of common interest, thereby strengthening the influence of technical men in matters of public welfare. The governing board will consist of the presidents of the member organizations. The individual sections will continue

to hold their separate meetings as heretofore, but members of any member section will be privileged to attend meetings of any other member section as guests. F. M. Chatard was appointed fifth member of the executive committee and H. Garner, A. Kennedy and E. B. Passano were appointed a meetings committee.

During the latter part of the evening Captain F. H. Wagner gave an address on the Recovery and Use of By-Products from Coal Tar. He illustrated the various processes of gas manufacture and by-product recovery and outlined the production of intermediates and final products. He described what had been done in this country in the development of benzol plants, aniline dye plants and plants for the production of explosives, illustrating by slides the apparatus and processes. At the close of the lecture American coal tar by-products were exhibited.

A. G. Christie,
Section Secretary.

BUFFALO, JANUARY 3

On January 3, 1917, over two hundred and fifty engineers, mechanical, electrical, civil, motor-car and others, celebrated the first convivial night of the Buffalo Engineering Society, and made merry until well after midnight.

Paul Wright,
Section Secretary.

BUFFALO, JANUARY 17

Highway Bridges was the subject of Chas. M. Spofford's address before the Engineering Society of Buffalo on January 17, 1917. He told of the great opportunity for engineers in the matter of standardization of the width of all bridges to be built, and quoted figures which proved that the increase in highway traffic during the last few years called for wider bridges. Relative to Buffalo's condemnation of several viaducts because of the effect of corrosion upon the floor supports, he claimed this was caused mostly by the forming of gas pockets in the understructures of railroad bridges. By means of lantern slides, Mr. Spofford showed various types of bridges, analyzing each design and describing various types of wearing surfaces and supports for wearing surfaces and the distribution of loads.

Frank D. Jackson, engineer of bridges and viaducts of Buffalo, followed Mr. Spofford with some of his experiences with bridges. He too advocated smooth understructures so as to eliminate gas pockets, stating that Buffalo had practically eliminated corrosion by applying red lead, sand and cement to the understructures of street viaducts.

Louis J. Foley,
Assistant to Secretary.

CHICAGO, JANUARY 5

Dr. Hollis addressed the Chicago Section at their meeting January 5, 1917, on the status of the engineer and his relation to society. His plea was for the recognition of engineering as a learned profession on an equality with medicine, law and theology. He outlined the difference between the various professions in their relation to the welfare of society. To him engineering is a constructive profession working for the welfare of humanity. He cited Eli Whitney and James Watt as instances where the work of individual men had changed the entire aspect of social and business life. Well's dictum "The history of humanity is the history of man's attainment to external power," he intepreted in the sense that the history of mankind is the history of invention, and invention is at bottom the practical expression of man's desire to benefit his fellow men.

Dr. Hollis concluded his remarks by outlining the relations that should exist betweeen the various local Sections of the Am.Soc. M.E. and other existing organizations of engineers in the same locality. He encouraged closer relations between such groups of engineecrs and held that the ultimate good of engineering demanded the closest coöperation of such organizations.

Robert E. Thayer,
Section Secretary.

CINCINNATI, DECEMBER 21

The Concrete Bridges and Viaducts of Cincinnati was the subject of the paper by Frank L. Raschig at a joint meeting of the Cincinnati Section and the Engineers' Club of Cincinnati, December 21, 1916. In outlining the activity of Cincinnati in the way of bridge and viaduct building, the speaker stated that since 1910 the city has expended about $2,000,000 for concrete bridges and viaducts. Four viaducts and fifteen bridges of lesser importance have been built and thirty small concrete bridges have replaced wooden structures. It is the settled policy of the Engineering Department of the city to build only concrete bridges and viaducts in the future, unless absolutely impracticable.

The Gilbert Avenue viaduct consists of 30-ft. spans of column, beam and slab construction, the entire structure supported on concrete piles. The structure is about 1200 ft. long and 80 ft. wide, with roadway 58 ft. wide. It cost, exclusive of property, $240,000 or about $2.40 per sq. ft. The main portion of the Ludlow Avenue viaduct consists of six solid barrel arches of 85-ft clear span built on a skew of 52 deg. with a roadway of column, beam and slab construction over these arches. The approaches leading up to these arches are of column and beam construction of 24-ft. spans. Length 1300 ft., width 60 ft. with 40 ft. of roadway, cost about $280,000 or $3 per sq. ft. The Hopple Street viaduct consists of a series of balanced cantilever beams arched in shape. A pier and the cantilever arms on each side compose a unit, the arms being balanced for dead load and for full live load. Length 1000 ft., width 60 ft. with 46 ft. roadway, cost about $450,000 or $3.75 per sq ft. An arch of 180-ft. span and consisting of three ribs, forms the main portion of the Park Avenue viaduct. The approaches are of column, beam and slab types with spans of 25 ft.

Mr. Raschig concluded his paper by stating that Cincinnati is planning to replace a certain number of wooden and steel structures each year so as to have finally none but concrete bridges

John T. Faig,
Section Secretary.

DETROIT, JANUARY 3

The first meeting of the Detroit Section was held on January 3, at the Board of Commerce, after a dinner given in honor of President Ira N. Hollis, at which over seventy engineers were present. Members of the local sections of the other national engineering societies and of the Detroit Engineering Society were invited to be present to greet Dr. Hollis and to hear him speak on the scope, purpose and opportunities of the local section.

Dean Mortimer E. Cooley, of the engineering department of the University of Michigan and president of the Section, presided. Before the address of Dr. Hollis, Dean Cooley called on several Detroit engineers for short talks. Those who spoke were Theodore A. Leisen, president of the local section of the American Society of Civil Engineers; A. A. Meyer, president of the local section of the American Institute of Electrical Engineers; Horace Lane, president of the Detroit Engineering Society; Clarence W. Hubbell, City Engineer, and Walter S. Russel of the Russel Wheel and Foundry Company.

Dr. Hollis took for the topic of his address the opening sentence of H. G. Wells' novel, The World Set Free—"The history of mankind is the history of the attainment of external power." He traced the development of machinery from the crude club wielded by the savage through the wheelbarrow, plow, steam engine, down to our present day complex machinery; and emphasized the fact that the progress made has always been toward the betterment of the condition of humanity. He stated that the engineer in his work sees not only the material outline of his machine as he works upon it, but sees back of his machine the relation it shares in the elimination of drudgery; and that the engineer in building his machine is like the painter in painting his picture who puts upon his canvas something besides a mere picture. "When I look at a copy of Millet's painting, the Angelus," said Dr. Hollis, "I see portrayed in the picture something of the struggle of humanity against nature and adverse conditions, something of the apparent futility of life in the face of eternity.

"Realizing the importance of their profession to all humanity, the engineers should make more of the esthetic aspects it presents. They should ever be willing in the public service. In their own ranks they should have complete organization for mutual benefit and to advance the condition of humanity by the efficiency among engineering men such organization should increase."

J. W. Parker,
Section Secretary.

INDIANAPOLIS, JANUARY 19

A joint meeting of the Indianapolis Section was held at Lafayette on Friday afternoon, January 19, in connection with the annual meeting of the Indianapolis Engineering Society and the Indianapolis-Lafayette section of the American Institute of Electrical Engineers.

The speaker provided by the Indianapolis Section of our Society was Harrington Emerson, Mem.Am.Soc.M.E., of New York, whose subject was Flow Values Through a Manufacturing Plant. This paper was illustrated by slides and covered Mr. Emerson's conception of the organization of a typical manufacturing industry in its financial aspect from the time of the assembly of the capital investment to the distribution.

The discussion of this topic by Mr. Emerson was as thorough and informing as would be expected by those who are more or less familiar with his expert services in the efficient organization of industries.

W. H. Insley,
Section Chairman.

MILWAUKEE, JANUARY 9

Dr. Ira N. Hollis, President Am.Soc.M.E., addressed the Milwaukee Section at their meeting, January 6, 1917, his subject being The Place of the Engineer and the Engineering Society in Modern Life.

Fred. H. Dorner,
Section Secretary.

NEW YORK, JANUARY 9

In line with the previous meetings of the season, the subject for the January 9, 1917, meeting was Industrial Preparedness in its Relation to Navy Yard Administration. The speaker, Commander E. P. Jessop, U. S. N., pointed out that provision has been made for those engineers beyond military age or otherwise disqualified to take up arms, to enroll for service at the navy yards in time of emergency and thereby release for sea duty the regular naval officers.

Departing somewhat from the announced topic, Commander Jessop proceeded to point out the citizen's obligations to his country and the vital necessity of every individual having his work mapped out beforehand because when trouble comes it usually comes at short notice. Scouting the idea that preparedness leads to militarism, he gave France as an example of democracy where individual liberty has not been marred by military training. England, who before the war was very much like ourselves, has taken two years to awaken to a realization of the situation and the British citizen is now fully alive to his obligations.

By way of showing some of the activities of the Navy, Commander Jessop gave a most interesting account, illustrated with slides, of the trip of the *U. S. S. Tennessee* to Europe at the outbreak of the war for the purpose of succoring refugees. He followed with views of the same ship when on a voyage to South American ports and showed finally the destruction of the ship in the harbor of Santo Domingo.

An informal discussion in which attention was directed to the need of more men to handle the new ships of the Navy, closed the meeting.

Alfred D. Blake,
Section Secretary.

PHILADELPHIA, DECEMBER 14

A joint meeting of the Philadelphia Section and The Franklin Institute was held December 14, 1916. Prof. Carl C. Thomas, Mem.Am.Soc.M.E., of Johns Hopkins University delivered an illustrated lecture on The Cooling of Water for Power Plant Purposes. He briefly reviewed the methods of cooling water, making special reference to efficiencies obtained by spray ponds. He described a new form of spray head and reported upon tests made under widely varied conditions. An interesting discussion followed which dealt with factors affecting the efficiencies of spray ponds.

W. R. Jones,
Section Secretary.

PROVIDENCE, DECEMBER 27

At the meeting of the Providence Engineering Society, Prof. Frederick H. Newell, Mem.Am.Soc.M.E., addressed the society on the work of the United States reclamation service in the far West. He illustrated his address by colored slides, explaining the engineering features of the Roosevelt, Elephant Butte and Arrowrock dams, their tunnels and the Gunnison River tunnel. The pictures also showed views of the new homes built on the irrigated land and, for comparison, the same country when it was the home of the Indian and the cowboy.

Albert E. Thornley,
Corresponding Secretary.

ST. LOUIS, DECEMBER 3

At a dinner given on December 3 by the St. Louis Section, Prof. Franklin Gephart gave a very interesting talk on Some Economic Aspects in Relation to the High Cost of Living. His talk was followed by discussions from a number of the members.

L. A. Day,
Section Secretary.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

At the meeting of the Student Branch of Armour Institute of Technology held December 6, 1916, interesting and instructive talks were given by several members of the Branch. The first subject presented was The Different Types of Automobile Engine Lubrication by L. A. King, followed by an explanation of the lubrication of the spring shackles on the new model of the Marmon automobile. R. A. Morse spoke next on the Manufacture of Water Gas, explaining the steps in the manufacture of the gas in a modern plant. The last speaker was Mr. Bretting whose subject was The Construction of Stacks.

E. W. Haines,
Branch Secretary.

BUCKNELL UNIVERSITY

The first meeting of the present school year of the Student Branch of Bucknell University was open to all who would attend. The purpose and workings of the branch were explained, and all who were not members were urged to ally themselves with it as early in their course as possible.

F. E. Burpee,
Branch Correspondent.

BUCKNELL UNIVERSITY

The regular meeting of the Bucknell University Student Branch was held December 11, 1916, when C. M. Kriner gave a talk on Jigs and their Application in Modern Machine Shops, illustrative of the simple type of jig as used for plain drilling and reaming, and the more complex type used in performing a number of operations on the work it holds. Mr. Weaver joined in the discussion.

During Thanksgiving vacation ten members of the Student Branch, accompanied by Prof. Frank E. Burpee, Mem.Am.Soc. M.E. and Prof. Taylor, made a six-day inspection tour to York, Lancaster, Philadelphia, Trenton and Wilkes-Barre, visiting various factories of mechanical interest. It was the most successful trip the Branch has taken during its history, and plans are on foot for conducting several of these tours each year.

J. A. Case addressed the Student Branch of Bucknell University at their meeting on January 8, 1917, on the Reservoir and Filtration Plant for the Jersey City Water Supply. He furnished some views of the reservoir and explained, by means of a blackboard sketch, the method of filtering and testing water for the percentages of the various kinds of bacteria.

C. M. Kriner,
Branch Secretary.

CARNEGIE INSTITUTE OF TECHNOLOGY

The Student Branch of the Carnegie Institute of Technology held its regular meeting November 15, 1916. Mr. Frederick Parke, Mem.Am.Soc.M.E., gave an interesting illustrated lecture on Brak-

ing, showing the development of brakes from their primitive type to the latest Westinghouse air brake used on the railroads of the country today. He also showed the tabulated results of many tests made on various railroads throughout the United States and pointed out that the development of the railroads followed very closely the development of the air brake, since the capacity of the brake determines to a large extent the permissible speed and weight of the equipment.

On December 13, 1916, the Branch heard a most interesting address by Lieut. J. B. Oldendorf, U.S.N., on Mechanical Engineering in the Navy. The speaker explained the considerations determining the design of various types of naval vessels and described in detail the installation of power plants abroad, battleships, cruisers, torpedo boats, destroyers and colliers. He indicated the design and arrangement of boilers, engines, turbines, pumps, etc., on naval vessels and gave his opinion that the internal-combustion engine of the oil-burning type is the marine engine of the future. He cited the successes experienced with this type of engine in submarines.

More than an hour of inquiries, questions and remarks on the part of the students evidenced the interest of the members of the Branch in the discussion which followed. The meeting closed with Lieutenant Oldendorf's recounting, on request, many interesting and amusing incidents experienced during his first cruise.

J. H. Davis,
Branch Secretary.

CASE SCHOOL OF APPLIED SCIENCE

The Value of the Engineer to the Community was the subject of the address of C. E. Drayer, Secretary Cleveland Engineering Society, before the Student Branch of the Case School of Applied Science on January 10, 1917. He emphasized the present-day need of engineers in the management of municipal affairs, citing the fire and building laws, street railways, water plants and power stations as instances where the skill and knowledge of the engineer should be employed. He showed by lantern slides a few newspaper columns on the value of the engineer to the community, explaining that the newspaper was the medium used by the Cleveland Engineering Society for bringing the relation of science and public affairs before the people.

Alex. Treuhaft,
Branch Secretary.

COLORADO AGRICULTURAL COLLEGE

At a meeting of the University of Colorado Student Branch, held November 27, 1916, Mr. Gorton gave a comprehensive talk regarding the measurement of steam by means of the orifice, U-tube and Ledoux bell type of meters.

E. C. Johnson.
Branch Secretary.

COLUMBIA UNIVERSITY

The Student Branch of Columbia University reports the successful carrying out of its project of uniting the Chemical, Civil, Electrical and Mechanical engineers under a joint governing board. The officers of the Branch are John L. Kretzmer, president; William M. Henry, vice-president; R. W. Thompson, secretary and E. H. Shea, treasurer.

John L. Kretzmer,
Branch President.

CORNELL UNIVERSITY

The Cornell University Student Branch began the new year with a very interesting meeting on January 13, 1917. The speaker of the evening was Prof. Dexter S. Kimball, Mem.Am. Soc.M.E., who gave an instructive address on the problems of the practicing engineer. He described some of the difficulties and stumbling blocks of young engineers, giving his personal experiences as a designer and consulting engineer.

S. M. Barr,
Branch Secretary.

COLUMBIA UNIVERSITY

The various engineering societies on the campus of Columbia University have been consolidated into an organization called the United Engineering Societies, which is controlled by a governing board composed of two delegates of each branch society. This consolidation was the outcome of a conference between the chairman and honorary chairman of the Student Branch of the Am.Soc.M.E. The Chemical Society was formed as a result of this consolidation and the Mining Society is expected to enter the organization shortly. The chairman of the Mechanical Society was elected chairman of the governing board.

The first meeting of the newly organized society took place December 14, 1916, and was in the form of a smoker which proved most successful. The speakers were Calvin W. Rice, Secretary Am.Soc.M.E., H. H. Norris, Charles Butters and Herman A. Metz.

John L. Kretzmer,
Branch Chairman.

LEHIGH UNIVERSITY

On December 14, 1916, an interesting meeting was held by the Student Branch of Lehigh University, which the Civil Engineers also attended.

Prof. Frank P. McKibben, head of the Civil Engineering Department of the University, spoke on the Hill-to-Hill Bridge to be erected between the Bethlehems. He covered the history of the means of transportation across the river and outlined the way in which the subject of a new bridge was taken up. He told how he had planned this new bridge and exhibited several of the first plans as well as the plans for the finished structure which, when completed, will be over a mile in length and will be Y-shaped, allowing for all traffic on both sides of the river. He estimated the cost to be about $1,000,000, most of which has already been pledged, so that the construction of the bridge is practically assured.

F. L. Benscote gave a comprehensive talk on Mechanical Refrigeration. He described the two types of refrigerating plants, the absorption and compression types, the latter of which is in more common use. By means of numerous blackboard sketches, he explained in detail the operation of the two types and the manufacture of artificial ice.

F. M. Porter,
Branch Secretary.

POLYTECHNIC INSTITUTE OF BROOKLYN

The Polytechnic Institute of Brooklyn held a meeting January 6, 1917 when The Development of Poppet Valve Uniflow Engines and their Status in the United States was discussed by Siegfried Rosenzweig, Mem.Am.Soc.M.E. He traced the development of the poppet valve uniflow engine from its origin to the present-day engines of Lenz and Stumpf. He gave as the reason for its great success, its non-destructibility under high pressure and high temperature, in which two phases it approaches in efficiency the explosion engine. Mr. Rosenzweig further favors it because there is no wear or rubbing and hence very little lubrication. He has endeavored to have locomotive manufacturers introduce these engines in their locomotives, but due to the fact that the concerns are busy manufacturing war implements, he has received very little encouragement.

The Institute has elected two men to represent the Society in editing the Engineer, their technical publication.

George Cherr,
Branch Secretary.

PURDUE UNIVERSITY

The Student Branch of Purdue University, at its meeting on December 16, 1916, was addressed by Dean C. H. Benjamin, Vice-President Am.Soc.M.E., of the Engineering School of the University, on the Thirty-Seventh Annual Meeting of the Society. His talk was general, giving a description of the Engineering Societies Building, the program which was carried out at the meeting and the method of presenting and discussing papers. He emphasized, as the great advantage of attending these conventions, the opportunity of meeting men, exchanging experiences and gathering pointers.

Geo. A. Ruess,
Branch Corresponding Secretary.

PURDUE UNIVERSITY

Dr. Ira N. Hollis, President Am.Soc.M.E., addressed the Student Branch of Purdue University on January 8, 1917. The basis of Dr. Hollis' talk was the title of H. G. Wells' book A World Set Free and he defined the engineer's responsibility for the "setting free." He especially emphasized the part played by James Watt in his improvement of the steam engine. Dr. Hollis ridiculed the idea of narrowness associated by many with the engineer and took issue with the writer of the statement that there is no romance connected with a machine. He claimed that the beauty of an engine is as real as the beauty of a picture for it is the "picture behind the picture" that makes a picture either famous or commonplace. Referring to Millet's Angelus, Dr. Hollis said that the human strife presented there would undoubtedly be present if the figures were replaced by broken machinery.

G. A. REUSS,
Branch Secretary.

THROOP COLLEGE OF TECHNOLOGY

On November 20, 1916, the Student Branch of Throop College of Technology conducted a meeting of the student body and faculty of the college, at which Charles V. Knight, inventor of the sleeve-valve motor, gave an instructive talk on the early development and mechanical features of his invention. Mr. Knight used a cut-away Stearns motor to illustrate the mechanism and operation of his motor.

REGINALD COLES,
Branch Secretary.

UNIVERSITY OF ILLINOIS

Dr. Ira N. Hollis, President Am.Soc.M.E., spent a part of Tuesday and Wednesday, January 9 and 10, at the University of Illinois, where he was the guest of Past-President W. F. M. Goss. Dr. Hollis was the guest of honor at a dinner tendered him by the Dean and heads of departments of the College of Engineering, where the president, vice-president and members of the council of the university, the local members and the president of the Student Branch of the Am.Soc.M.E., were also guests.

In Dr. Hollis' address before the Student Branch, he aimed to impress upon the young men the dignity of their calling and the significance of the engineer as a factor in the social, political and economic progress of the nation.

W. F. M. GOSS,
Branch Correspondent.

UNIVERSITY OF NEBRASKA

At the November, 1916, meeting of the Student Branch of the University of Nebraska, M. F. Clark gave an address on the Relation of the Engineer to National Preparedness, presenting the questions involved and some of the views expressed by the most prominent engineers on this subject. Foundry Practice was discussed by Mr. Smith, instructor at the University in that branch of work. He was followed by Prof. J. D. Hoffman, Mem.Am.Soc.M.E., who spoke on the Chicago Edison Plant, reviewing Mr. Insull's paper in THE JOURNAL, November, 1916, on that plant and adding his own observations from a personal inspection of the plant.

ORLO A. POWELL,
Branch Secretary.

UNIVERSITY OF MISSOURI

The Relations of the Student Branch to the Society and the advantages realized by taking an active part in the Society, were discussed by Prof. H. W. Hibbard, Mem.Am.Soc.M.E., at the first regular meeting of the Student Branch of the University of Missouri, held October 26, followed by an illustrated lecture by D. E. Foster, Associate Professor in Mechanical Engineering, on Air Compressors and their various uses.

Louis Seuter was elected chairman for the year 1916-1917; B. W. Coots was elected treasurer and recording secretary, and C. N. Johns was elected corresponding secretary.

At the second meeting of the Branch, held November 9, M. H. Brigham, Assistant in Manual Arts, gave an interesting talk on Shop Practice, laying special stress on the production of machinery.

C. N. JOHNS,
Branch Secretary.

VIRGINIA POLYTECHNIC INSTITUTE

On December 8, 1916, the Student Branch of Virginia Polytechnic Institute held an interesting meeting, at which Frank B. Gilbreth, Mem.Am.Soc.M.E., gave a talk on Motion Study as a means of increasing the efficiency of operators and workmen in various occupations. Mr. Gilbreth cited several instructive instances of his observations for practical application of his method of corrected motions.

The method by which Mr. Gilbreth's observations are made is that of taking moving pictures of the operator at his work. In the background of the picture, a screen resembling a sheet of coördinate paper is placed; a light attached to the operator's hand traces a line across the screen; the graph thus obtained is studied and a wire model of the curve is made. By means of this model the shortest distance in which the space may be traversed is determined, and by instructing the operator to adopt motions in accordance with the corrected motions, his efficiency is many times increased.

By following Mr. Gilbreth's methods, three typists won the first and second international, and the first national speed prizes, and the golfers Nichols and Ouimet derived considerable benefit in their work.

G. E. PARKER,
Branch Secretary.

WORCESTER POLYTECHNIC INSTITUTE

On January 5, 1917, the Worcester Polytechnic Student Branch held a joint meeting with the student branches of the American Institute of Electrical Engineers and the Civil Engineers Society. The subject of the day was From Ore to Finished Pipe, by H. T. Miller, of Boston, who illustrated his lecture with motion pictures.

H. P. FAIRFIELD,
Branch Secretary.

Am.Soc.M.E. Year Book, 1917

The new Year Book of the Am.Soc.M.E. is off the press and will be issued early in February. The volume contains general information regarding the Society, its objects and activities, calendar of events for 1917, the personnel of the Officers, Council and Committees for the year, together with the alphabetical and geographical lists of members of the Society, corrected to January 1, 1917. A list of past officers and a calendar of all general meetings since the first meeting in 1880, a list of depositories for Transactions, also the Charter and By-Laws of the Society are included in addition for reference.

The alphabetical list of members occupies 302 pages and contains 7,704 names. This is an increase of 773 over last year. The geographical list extends over 170 pages.

Attention is called to the scheme of the alphabetical and geographical lists. In the alphabetical list are given the grade of membership in the Society, the title and business connections, the business and residence addresses. In the geographical list are given under each city or town, the names and business connections of members; experience has shown that this is the information most likely to be required from this list.

Every member of the Society receives a copy of this Year Book, bound in cloth. The geographical list of members is also issued as a separate publication, bound in paper.

EMPLOYMENT BULLETIN

THE SECRETARY considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping any-one desiring engineering services. The Society acts only as a clearing house in these matters.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed with the Society. Copy for notices must be in hand by the 15th of the month.

ASSISTANT CHIEF ENGINEER. Young man who has had experience in or made special study of power plant operation, to assist in running woodworking factory of 1000 hp. Knowledge of design of exhaust steam-heating on large scale desirable. Answer, stating age, past positions and salary expected. 83

DRAFTSMAN experienced in design of heavy machinery, rolling mills, etc. Location Connecticut. 98

YOUNG ENGINEER DESIGNER with technical education and special training in the design of automatic machinery for the manufacture of small interchangeable parts; excellent chance for advancement to one who displays ability and application. Location Chicago. 139

RECENT GRADUATES in mechanical engineering from schools of recognized standing desired for testing work in large steam-operated electric power plants. Preference will be given to applicants with experience in testing work and those now located in and around New York. Answer stating particulars of education, experience and salary desired. 167

TOOL DESIGNER who is resourceful and can follow work through to completion. Technical man with practical shop experience. Salary $25 to $35 per week according to ability. Location Connecticut. 185

SALES ENGINEERS, young men, between ages of 25 and 30 years, of good appearance, graduates of some approved engineering college, preferably M.E. degree. Applicant would be expected to undergo a period of probation and training in the various offices of company before being given more responsible and higher positions in sales work. Apply by letter in own handwriting, stating age, education, previous business training, if any, salary desired, etc. Location New York. 205

DESIGNER for special machinery and labor-saving devices, capable of following work through shop to completion. Location New York State. 248

SALES ENGINEERS or AGENCY on commission for one who is handling other lines, desired for the following territories: Tennessee, North Carolina, Minnesota, North and South Dakota. Past record must show familiarity with boiler plant practice. 433.

WORKS MANAGER, unusual opportunity for right man, 35-45; must be graduate engineer and have thoroughly demonstrated ability as machine designer and production man. Good organizer and hustler, preferably with ability to invest $5,000 at the end of 3 months if satisfactory. State fully education, experience, age, etc. Correspondence strictly confidential. 642

DRAFTSMEN. Experienced mechanical draftsmen, preferably not over 30 years of age. Permanent employment and advancement to capable men. Location New York State. 751

POWER ENGINEER for large industrial corporation operating its own steam and electrical power plants; young man with executive ability, mechanical or electrical engineering graduate, experienced in power plant and power distribution, design and operation. State age, school, year of graduation, detailed experience and salary expected. Location Michigan. 763

ENGINEER, experienced in manufacture of interchangeable parts, with thorough knowledge of die and tool design. Location New York. 764

DRAFTSMAN, familiar with power house work, such as the installation of its equipment, piping, etc., competent to work out the different problems involved. Salary $25 to $28 per week. Location New York. 769

SHOP INSPECTOR, over 30 years of age, competent to take charge of factory of 500 men, manufacturing large quantities of varied equipment; to represent New York office. Salary according to man. Location Massillon, Ohio. 770

ENGINEER skilled in handling of materials, to study the handling of materials at plants of large industrial corporation; experience with conveying machinery and other mechanical means of handling transporting materials. 782

HEATING AND VENTILATING ENGINEER to study heating and ventilation and various similar problems at plant of large industrial corporation. 783

CONSTRUCTION SUPERINTENDENT for contracting company engaged principally in municipal contracting. Applicant must be capable of handling men in water works and sewer construction and able to take a financial interest in the company. Location Middle West. 784

YOUNG ENGINEER to keep up machinery and design improvements and attachments for machines now running and design new machines as thought desirable. First work will be to assist in giving lines and positions of building construction now under way. Position will pay $40 per week to start, and as soon as results are obtained a responsible position with adequate compensation will be established. Location New York State. 785.

MECHANICAL ENGINEER who would be interested in partnership in established business dealing largely in apparatus pertaining to economical production of steam, as recording instruments, steam meters, water meters, calorimeters for fuels and gases, etc. Location New York. 736

SALES ENGINEER with experience, for Chicago Branch Office of concern manufacturing power-plant specialties, high-grade valves, jet apparatus, condensers, sprays, heat-transmission apparatus, oil-firing equipment, etc. Give full particulars and references. 793

DESIGNER on fittings and valves. Good draftsman with executive ability, capable of taking charge, but willing to work. Answer stating age, education, salary expected, previous positions and references. Location New York State. 794

ENGINEER familiar with application of handling equipment in general factory work. 795

DRAFTSMAN on boiler and stoker work. Two or three years' experience. Location New York. 797

ASSISTANT PROFESSOR OF MECHANICAL ENGINEERING, with five or more years' practice in gas or steam engineering design or construction and teaching experience, for technical institution. Position open now or in September, 1917. Location Pennsylvania. 798

STAFF ENGINEERS, experienced in manufacturing efficiency work, especially in routing, motion-study, time-study, rate-setting and introduction of bonus systems. Salary $150 per month. Location Chicago. 799.

YOUNG ENGINEER to assist in installing Gantt system in light industry employing both men and women. Prefer man who has had experience along this line. Location Georgia. 800

DRAFTSMEN familiar with power-plant design, piping layouts, foundation work, light structural-steel work and timber-platform construction, especially with experience in the design, of chemical plant equipment. Location Brooklyn. 803

MACHINERY DESIGNER to take charge of drafting force. Must have good and extensive experience in building machines for working sheet metals, as presses, shears, etc. Salary $225 to $250 per month. Location, Buffalo, New York. 804

DESIGNER on heavy machine tools and similar machinery. Good opportunity for high-grade designer with chiefly drawing-office experience. Location Pennsylvania. 40

ASSISTANTS TO CONSULTING ENGINEER, recent graduates from high-grade engineering school. Personality and correct use of English as

essential as technical training. Moderate salary with advancement. Answer in own handwriting with complete record of training. Location Ohio. 805

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 15th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

RECENT TECHNICAL GRADUATE, now employed, desires to change position to one in which there is good opportunity for advancement. B-49

TECHNICAL GRADUATE, in charge of erection and design of plant and equipment for large chemical concern, wishes to change. Energetic; can purchase equipment to good advantage and install it to most economical utilization of floor space. Familiar with mechanical methods of storing and handling material. Available on reasonable notice. Salary $2100. B-50

MANAGER or SUPERINTENDENT where ability can be demonstrated and where there is an opportunity for advancement. Associate-Member; graduate mechanical engineer. Three years mechanical engineer of large steel company; two and one-half years chief engineer of electric company; two years in consulting engineering profession. Best references furnished. B-51

MECHANICAL ENGINEER with extensive acquaintance in Eastern territory would like to represent manufacturers who desire to increase their sales in the East on purely commission basis, or would form partnership with established firm of manufacturers' agents. At present employed. Salary $5000 to $10,000. B-52

ENGINEER-SALESMAN for concern desiring new business or development of special department. Capable of approaching with confidence architects and engineers or owners on larger construction operations in New York or New England and nearby states. B-53

NEW YORK SALES MANAGER, age 33, wants position with company capable of turning out special machinery, principally sugar machinery. Long experience and large clientele. B-54

WESTERN REPRESENTATIVE. Member, practical machinist, Stevens graduate. Age 36, married. Easterner with residence of ten years in the West. Engineering business and buying experience. Now employed by mechanical engineering contracting concern. Desires change and solicits position as Pacific Coast representative of Eastern manufacturer. Salary and commission basis. Would consider two non-conflicting lines. References. B-55

INSTRUCTOR or DIRECTOR. Member. Technical education and over twenty years' practical experience. At present superintendent of industrial school. Desires position in vocational or industrial school, eastern part of United States preferred. Salary $1800. B-56

SUPERINTENDENT or ASSISTANT MANAGER. Twenty years' experience on large variety of machine works. At present superintendent in a large plant. Desires position with machinery manufacturing concern. New England preferred. B-57

SALES ENGINEER. Mechanical engineer opening sales office in Detroit in near future wishes to handle complete line of power-plant machinery and specialties on salary or commission basis. Must have liberal commissions. Will push a good line and secure results. References. B-58

ENGINEER desires position as assistant manager or superintendent. Will consider position as chief engineer or resident engineer. Location immaterial. B-59

MECHANICAL ENGINEER who has done considerable consulting, general plant layout and supervision desires to make new connections with responsible concern or established office. B-60

ASSISTANT to PRODUCTION or EFFICIENCY EXECUTIVE. Technical graduate, age 27. Five years' experience in machine shop, drafting, and designing. Familiar with modern production methods and possesses originality, integrity, and accuracy. Desires permanent position with progressive company. Location immaterial. B-61

PROFESSOR OF MECHANICAL ENGINEERING, technical graduate, age 40, M.E., with 17 years' experience in teaching, engineering and consulting work. Practical experience in commercial engineering; specialized in steam power plants. For a number of years head of department of mechanical engineering in leading university. At present head of departments of mechanical and electrical engineering in university of good standing. Location abroad, China preferred. B-62

CHIEF ENGINEER, EXECUTIVE or MASTER MECHANIC. American, age 38. Held positions of chief engineer for two large chemical works. Fifteen years' experience handling men and production in large plants. Thorough shop and foundry man; also power-house engineer, competent to assume full charge of all mechanical work in a large plant. Desires position with a large industrial plant or other responsible position. Highest references; can prove ability. B-63

SUPERINTENDENT. Member, graduate in mechanical engineering. Thoroughly familiar with current practice affecting superintendency of medium-sized plant. Would consider change from present position, providing a small investment in the business would be considered. Location desired, Chicago. B-64

MECHANICAL ENGINEER or ASSISTANT MANAGER. Associate member, age 38. Twenty years' experience as shop foreman, chief draftsman, master mechanic and engineer. Has designed, constructed and operated machine shops, car shops, power and sub-stations, pumping plants, air-compressing plants, fire-protection systems, etc. Several years' experience designing and building conveyors, electric locomotives, cars, trucks, hoisting machinery, foundations, structural-steel work, and buildings. Competent to assume responsibility and produce results. Plant now erecting about completed. Available in thirty days. Salary $3000 per annum. B-65

EFFICIENCY ENGINEER. Technical graduate, age 32. Eleven years' experience, covering construction and operation of power plants and central stations. Specialty, boiler economy; can furnish excellent references on this point. Now seeks engagement with firm desiring results that a capable engineer—not a magician—can produce. Minimum salary $250 per month in United States and $300 and expenses elsewhere. B-66

SUPERINTENDENT or ASSISTANT GENERAL MANAGER. Mechanical engineering graduate, age 27. Technical apprenticeship with motor-truck company. Successful experience in designing, handling men, increasing production, reducing costs and installing modern methods. Some purchasing and selling experience. Now employed as superintendent by well-known concern manufacturing large and small interchangeable-part machines. Desires better opportunity for future. B-67

MECHANICAL ENGINEER. Graduate University of Illinois, age 35, married. Five years' practical experience in shops, engineering and sales offices. Five years' outside erection, inspection, trouble work, and testing of power-plant equipment and accessories, including boilers, Corliss, oil and gas pumping engines, steam turbines, condensers, electrical equipment. Thorough, capable and aggressive, possessing executive ability and eager for responsibility where results are desired. Prefers position with consulting engineers or firm requiring traveling constructor, inspector, tester or sales engineer. Best of references from past and present employers as to integrity, honesty and ability. B-68

SUPERINTENDENT, MASTER MECHANIC or EQUIPMENT ENGINEER. Age 33. Fourteen years' experience in drawing and stamping of sheet metal. At present assistant equipment engineer in plant having 10,000 employees. B-69

COMBUSTION ENGINEER. Technical graduate about to end four-year term as head of smoke-inspection department of large city, desires to connect with some concern to whom his experience would be of value. Prominent in national smoke-abatement movement. B-70

PUBLICITY ENGINEER. Mechanical graduate, age 33, married, excellent health. Thoroughly experienced in the advertising of mechanical equipment. Expert in the preparation of sales literature, trade paper advertising, and sales correspondence. Minimum salary $200 per month. Available for interview any time in New York City or vicinity. B-71

MECHANICAL ENGINEER. Associate-Member, age 30, technical training. Three years on civil engineering work: foundation, concrete, steel, building and power-house erection. Four years' mechanical engineering experience, on boilers, engines, special apparatus, hydraulic machinery, shop work, producer-gas engines and generators, industrial plant work. Two years in electrical work, on a.c. and d.c. generation, transmission and distribution. Good executive, desires to specialize. B-72

EXECUTIVE ENGINEER, ASSISTANT TO EXECUTIVE OFFICER or CONSULTING ENGINEER. Graduate of leading technical school. Twelve years' experience as special engineer in shop, factory, sales and general office administration work. Good organizer and experienced in directing men. B-73

JUNIOR MEMBER. Stevens graduate, with varied experience in the development of machinery and scientific inventions, wishes to connect with aeroplane or automobile manufacturer. At present engineer for a large electrical manufacturing company. Available on reasonable notice. B-74.

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

Arranged in the Order of Their Appearance in the Survey.

Particular attention in this issue is called to the section Internal-Combustion Engineering, especially the abstracts of articles on the development of the use of Diesel engines in shipping, both in America and in Europe. It is unfortunate in this connection that the data of the article in *Motorship* describing the motive power of the M. S. *Deutschland* are so obscure. With all this, however, the article represents a good example of enterprising work in the field of engineering journalism and contains data which are not otherwise available.

THIS MONTH'S ARTICLES

In a paper before the Annual Meeting of the Society of Automobile Engineers, now transformed into Society of Automotive Engineers, Capt. V. E. Clark and his associates in the Signal Corps present a brief discussion of some problems in aeroplane construction. This paper is in line with the policy inaugurated by Col. George O. Squier (compare his paper presented in the Engineering Survey for January, 1917) of inviting the collaboration of the engineering profession at large in the working out of technical problems by the Aviation Branch of the War Department.

In the section Engineering Materials attention is called to an advance notice of a technological paper of the Bureau of Standards on the manufacture and properties of sand-lime brick.

In the same section will be found an abstract of a paper on Heat Treatment of High-Speed-Steel Tools, the authors of which show how important it is to carefully control the hardening temperature and to apply to each particular steel the proper heat treatment.

The Resistance of Lubricating Oils to Emulsification is discussed in another advance abstract of a technological paper of the Bureau of Standards, where it is stated that the majority of the oils on the market are either very good or very poor. A stirring test is suggested as being more sensitive than chemical tests only.

Sawdust Firing on a large scale as practiced at the Singer plant at South Bend, Indiana, is described in an abstract from an article in *Power*.

From the *American Gas Engineering Journal* are abstracted data of interesting experiments on the measurement of flow of unpurified gases at high temperature by means of pitot tubes, which show that the flow of hot gas can be measured in this way and that the temperature of the gas does not apparently affect the tube or interfere with the indications of the gage, at least when the measurement is carried on for a limited period of time.

In the section Hydraulics are described experiments on the effect of sudden enlargement upon the flow of water in pipes, likewise conducted by means of pitot tubes. In this case a special attachment described in the abstract was used for facilitating the set of the tube. A modified Borda formula is suggested for expressing the loss of head in feet due to sudden enlargement.

In the same section is presented an abstract of a paper on the Determination of Capacity and Design of Wood-Stave Pipe.

A novel two-cycle two-cylinder oil engine developed in this country is described; it is characterized by the employment of a cylinder in which operate two working pistons opposite to each other. A special arrangement for uncovering the exhaust ports is used.

Several abstracts are presented on Diesel engines. From a Bulletin of the Iowa State College are abstracted data obtained from a study of oil engines in Iowa power plants.

Another abstract describes in detail the matter of piston and small-end lubrication in Diesel engines. This discussion covers the subjects of selection of lubricating oil and design of lubricating system.

A paper read at the Annual Meeting of the S.A.E. by Prof. Walter T. Fishleigh and W. E. Lay presents data of a very interesting investigation of the heat-balance performances of automobile engines, including a complete heat balance for certain runs.

Locomotive-axle failures due to improper manufacture are discussed in an abstract from the report of an engineer of the Interstate Commerce Commission.

The erosive effect of steam on turbine-blading material formed the subject of an investigation carried out in the

post-graduate department of the Naval Academy. While the investigation was only of a preliminary nature, the data obtained are already of considerable interest.

Another article in the same section, Steam Engineering, describes the use of Curtis steam turbines and Alquist reduction gears in the propulsion of cargo ships. From an article abstracted from the *General Electric Review* it appears that the abnormal conditions of American freight shipbuilding are now all favorable to the development of standardized production and to the use of the class of machinery here described. Data are presented on the comparative economy of reciprocating-engine- and turbine-propelled cargo ships, showing considerable economy in favor of the latter class.

The Moore steam turbine, a newcomer in this line of production, is described from an article in *Power*.

From an article in *Engineering* is abstracted a discussion of the Willans Line for Steam Turbines, where it is shown how to obtain a corrected Willans line, and what a corrected line represents.

Aeronautics

Some Problems in Aeroplane Construction, Capt. V. E. Clark, Capt. T. F. Dodd, and O. E. Strahlmann

Enumeration with brief remarks of some important problems connected with the construction of aeroplanes intended for military use in the United States, some of these problems also applying, however, to aeroplanes built for commercial and sporting purposes.

The paper gives definitions of the main classes of military aeroplanes, viz., strategical-reconnaissance machines, tactical-reconnaissance machines, field-artillery fire-control, long-range bombers, pursuit machines and over-sea reconnaissance machines.

As to problems in construction, the question of two propellers is discussed in some detail. Methods of reducing the vibration are touched on somewhat cursorily. Gasoline-supply systems, on the contrary, are discussed in considerable detail and illustrated by drawings.

Of the other subjects, the following are touched on more or less: Metal construction for aeroplanes; flexible piping; muffler requirements; shock absorbers for landing gear; brakes required when landing; floating landing gear; gasoline-supply gage; fire safety devices; altitude adjustment for carburetor; firing machine gun by engine shaft through the disk of the propeller; variable radiators; ignition and cooling systems.

The paper discusses in particular detail the two important problems of variable-camber wing and propellers with variable pitch angle.

The question of propeller stresses is also discussed in detail and illustrated by several curves indicating the various stresses at various points of the propeller. (*S. A. E. Bulletin*, vol. 11, no. 3, December 1916, pp. 213-236, 15 figs., *g*)

Engineering Materials

The Manufacture and Properties of Sand-Lime Brick, Warren E. Emley

Sand-lime bricks are made of sand and lime, hardened by exposure to the action of steam at high pressure. They compete in numerous localities with common building bricks made of clay. There is a widespread demand for information as to just what sand-lime bricks are, how they are made, and what properties one may expect them to have. In this paper an attempt has been made to compile this information and make it accessible. A short theoretical discussion leads to certain conclusions as to the desired properties of the raw materials —sand and lime. The different steps of the process of manufacture are then taken up in detail, and comparisons made of the different mixing, pressing, and hardening operations as carried on in various factories. The testing methods generally employed for the examination of common building bricks are described in detail, and a summary is given of the results obtained when sand-lime bricks are subjected to these tests. An appendix contains detailed descriptions of the equipment of seven typical factories. (Abstract of *Technologic Paper* no. 85, Bureau of Standards)

Identification of Light-Gray Inclusions, George F. Comstock

There seems to be a common opinion among metallographists that all light-gray inclusions seen with the microscope in polished sections of steel are manganese sulphide. Slate-colored inclusions are considered to be silicates, and dove-gray inclusions manganese sulphide. This, however, is not correct, and scale which is apt to accumulate along the edge of any piece of steel if it be well polished and preferably unetched, will show light-gray in appearance. As a matter of fact, however, it is not manganese sulphide at all but chiefly iron oxide, and contains sulphur only as an impurity.

It therefore becomes important to find a method of distinguishing oxides from sulphides. It has been found that this can be done by the use as etching material of boiling alkaline sodium picrate, which produces blackening of the sulphides. This action seems to be due to an actual solution of the manganese sulphide by the etching liquid, so that instead of a smooth, polished surface we now have a surface full of pits or hollows where the sulphides were, and as these hollows do not reflect any light back into the microscope with vertical illumination, they appear black in the field of vision.

At the same time this liquid does not attack oxide inclusions at all. A further advantage of the use of this solution for the described purpose is that it is already used for etching cementite in high-carbon steel and is, therefore, familiar to metallographists.

The article contains numerous microphotographs showing the application of the described method, (*The Iron Trade Review*, vol. 59, no. 24, December 14, 1916, pp. 1195-1197, 17 figs., *eA*)

Notes on the Heat Treatment of High-Speed-Steel Tools, A. E. Bellis and T. W. Hardy

The problem of heat treatment of high-speed steel becomes increasingly important as the design of cutters becomes more and more complicated with the growth of efficiency of mechanical operations. While hundreds of dollars are spent in the design and manufacture of milling cutters of special form for rapid production of duplicate or interchangeable parts, the final efficiency of the operation depends on the ability of the tool to perform the work, and this in its turn depends on the heat treatment given it. In order to be on the safe side, the average tool hardener uses a temperature much too low to give the best results with the high-speed steel he uses. In the case of cutters which are finished to a given diameter before hardening, it is impossible to grind the tool after hardening, so that it is essential that the surface be

protected from oxidizing or decarbonizing. In this paper are described some experiments on hardening high-speed steel in which metallographic means were used to determine the correct hardening temperature.

Six specimens from the same bar of each kind of steel (5 kinds were taken) were hardened from different temperatures and photomicrographs made. The temperature from which the piece was hardened is given under the photomicrograph in each case (cp. Fig. 1). Photographs were made of the longitudinal section, care being taken to grind off the outer surface. The specimens ¼ in. square in section were first preheated at 1500 deg. fahr. and then quickly placed in the high-speed furnace already heated to the desired temperature, left at this temperature for one minute, and quenched in oil.

In interpreting the micrographs the author regards that at 2100 deg. fahr. as a dark matrix showing a large excess of free carbide; as the temperature is raised, more and more of the carbide dissolves and the network structure of austenite is more noticeable.

In general, the steels that show some excess carbide even at the maximum hardening heat are the most efficient. These as a rule are the steels with high tungsten content; they harden from a higher temperature and over a wider range than the lower-tungsten steels, and for this reason do not require as careful treatment as the latter. On the other hand, the steels with lower tungsten and higher vanadium give better results when hardened at the lower-tungsten temperatures than do higher-tungsten steels when these are hardened at the same low temperatures. The comparison is not so advantageous to the lower-tungsten steels when the steel with higher tungsten is given the proper hardening heat.

It is highly important to carefully control the hardening temperature and to apply for each particular steel the proper temperature. The custom of using only one "high-speed temperature" for all steels is very poor practice.

A good deal of trouble is experienced in hardening through oxidation at high temperatures. The use of a barium chloride bath to eliminate this difficulty has the disadvantage that the surface of the tool becomes decarbonized. A method that has proved satisfactory is to place the tools, after preheating, in the reducing temperature of a carbon-resistance electric furnace already heated to the required temperature. The very short time necessary to get the tool to the temperature of the furnace eliminates injurious surface effects.

The increased efficiency and cutting power of tools that have received the proper heat treatment are out of all proportion to the time given to the study of the particular steel involved and to the care given the work. (*Bulletin of American Institute of Mining Engineers*, no. 121, January 1917, pp. 61-68, 5 plates. *epA*)

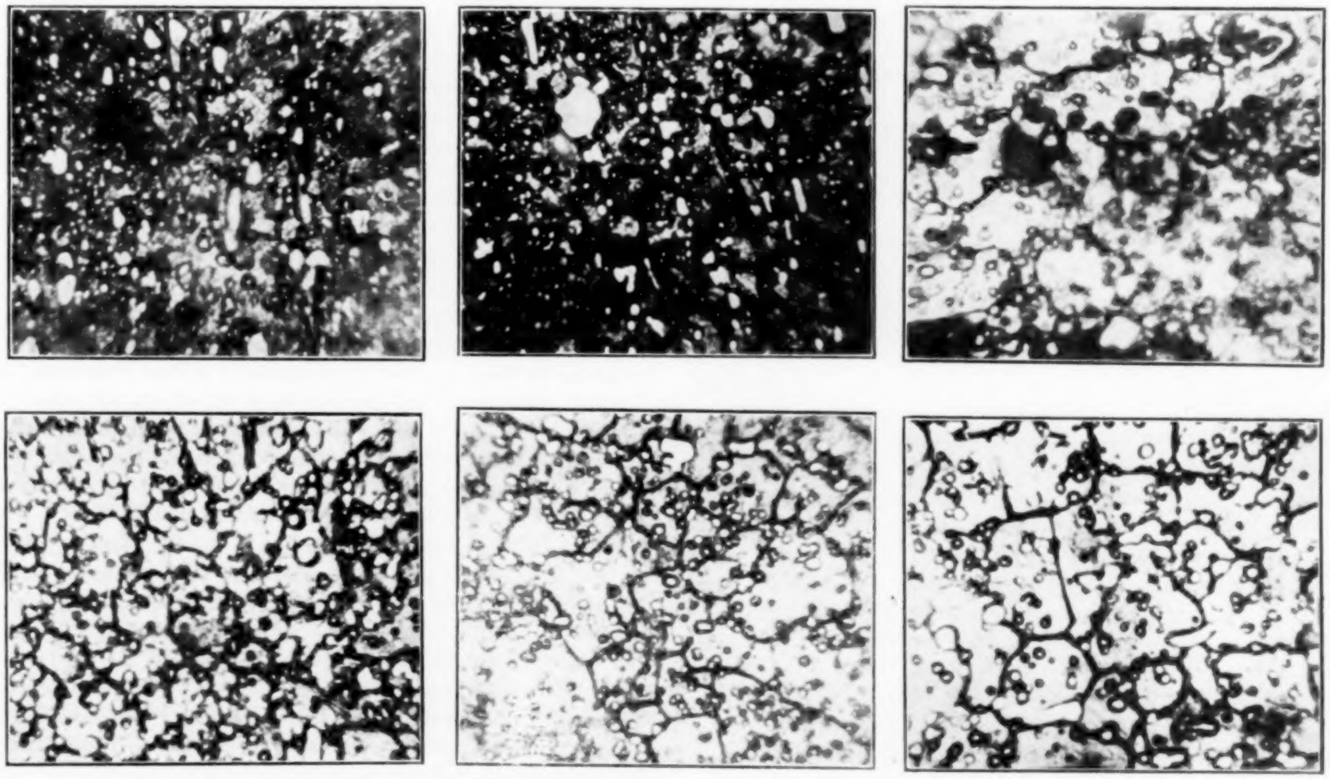


Fig. 1 Microphotographs of Specimens of High-Speed Tool Steel Treated at Various Temperatures

Upper Row (from left to right): 2050, 2100, 2200 deg. fahr. Lower Row (left to right): 2250, 2300, 2350 deg. fahr.

Report of Committee on Specifications for the Purchase and Preservation of Treatable Timber

Only parts of this report are here abstracted.

As regards the selection of preservatives, the report states that from the standpoint of permanent protection of wood against decay and marine borers, coal-tar creosote is the best available preservative for general purposes. It possesses the necessary theoretical requirements and has stood all practical tests through many years' use under varying conditions of service and in many different kinds of materials.

Zinc chloride is of great importance as a preservative and deserves full consideration in regions of low precipitation, in dry sections, and where general low cost is essential. While

the life of zinc-treated material is usually less than that of creosoted, the expense is also less.

Factors to be considered in comparing preservatives:

1 The toxicity of the preservative, namely, its ability to prevent decay.
2 The ability of the preservative to penetrate the wood.
3 The permanency of the preservative in the wood.
4 The effect of the preservative on the strength of the wood.
5 The effect of the preservative on the corrosion of spikes and plates, and the operation of block signals.
6 The cost of the preservative.
7 The uniformity in composition of the preservative and the ease of securing it.
8 The combustibility of the preservative.
9 The ease of handling the preservative and wood treated with it.
10 The ease with which the penetration of the preservative can be determined.

In treating with creosote it is recommended that a maximum injection of creosote sufficient to insure the penetration of all treatable wood be required. All the sapwood and as much of the heartwood as is possible for the particular species shall be thoroughly impregnated. This applies equally to full-cell and empty-cell treatments.

In treating with zinc chloride it is essential that all timber be treated to refusal.

As to selection of treatable timber, the fundamental requirements of structural timbers for treatment are strength and capacity for treatment to an extent which will insure protection against decay on all exposed surfaces. A penetration of one-half inch on the heart faces may be recommended as a safe minimum on structures above ground.

The report covers also the subjects of restrictions on knots, shakes, checks, cross-grain, sapwood, etc.; track ties; piles; preparation of timber for treatment, and treatment proper. (Abstracted from advance copy of report to be made at the Annual Meeting of the American Wood Preservers' Association in New York, January 23-25, 1917.)

The Resistance of an Oil to Emulsification, Winslow H. Herschel

In forced-feed lubrication, such as is used with high-speed engines and turbines, there is often trouble due to the emulsification of the oil. Service tests are not practicable, on account of the time and trouble involved, so that there is great need of a laboratory test. Moreover, it is highly desirable that the test should make it possible to express the resistance of an oil to emulsification by a single numerical value, as experience has proved that it is almost impossible to enforce in a contract any less definite specification.

A study of the literature showed that though several emulsification tests were described, they were all more or less indefinite, and no one of them was in general use. It was therefore necessary to devise an entirely new test, which may be briefly described as follows:

Twenty cubic centimeters of the oil to be tested, and double that volume of distilled water, are heated to 55 deg. cent. (130 deg. fahr.) in a 100-cc. cylinder of 26 mm. (1 in.) inside diameter, and stirred for five minutes at a speed of 1500 r.p.m. The paddle is simply a plate of metal, 89 x 20 x 1.5 mm. (3½ x 13/16 x 1/16 in.), approximately. Since the test is not sensitive to slight changes of paddle dimensions, they need not be exact, and no calibration is required. The cylinder and contents are allowed to stand at the same temperature, and readings are taken at more or less frequent intervals (according to the type of oil) of the volume of oil settled out from the water. From these readings a maximum rate of settling, called the "demulsibility," is easily taken from a table.

A German test, used for steam-engine cylinder oils, would appear at first sight to discriminate against the good oils containing compounding in the attempt to eliminate the poor oils which contain soap. Examination of the experience with the test, however, shows that the method of agitation is not very effective, so that only oils which contain soap will emulsify. Good oils, even if they are compounded, will not emulsify. The test here described might be so modified as to make it applicable to steam-engine cylinder oils, but this has not yet been attempted, and in considering the results obtained with the test for demulsibility, compounded oils have been omitted, except where noted.

It has been found that the majority of oils on the market are either very good or very poor. The best transformer, dynamo and turbine oils settle out in a minute or less, thus showing a demulsibility of 1200 cc. per hour, which is the highest value on the arbitrary scale adopted. On the other hand, when an emulsifying marine-engine or crank-case oil is tested, no oil will settle out of the emulsion up to the end of the hour that the test is continued, and the demulsibility is recorded as zero.

Comparison with chemical tests shows that the stirring tests are the more sensitive, and this is in agreement with the experience of others. This explains why it has been such a troublesome problem to chemists, why one oil would emulsify and the other would not, when according to their tests, both oils were equally pure. The stirring test shows that a minute amount of impurity, which cannot be detected by chemical means, will cause a marked increase in emulsification.

Oils which have a suitable demulsibility will not emulsify in use, but there is still the trouble that, after a considerable length of time, they may disintegrate and deposit sediment, due to oxidation, polymerization, or some other similar chemical change. On this account an investigation of used oils was undertaken, and it was found that there was a marked decrease in demulsibility with continued use. The conditions of operation are so different in different power plants that exact values can not be given for the rate of deterioration to be expected, but it is believed that the test should prove of great assistance to power-house engineers in keeping track of the deterioration of the oil in their plants. (Abstract of *Technologic Paper* no. 88, Bureau of Standards)

Fuels and Firing

New Method of Indicating Density of Smoke, as Installed on the U. S. S. *Conyngham*, Rear-Admiral R. T. Hall, U. S. N.

The system installed on the after stack of the ship consists of a light transmitter installed on one side of the stack, a light receiver installed on the opposite side, and an indicating meter with suitable control appliances installed in the boiler room.

The basic principle of operation of the system is dependent on the peculiar property of selenium, namely, that its electric resistance is inversely dependent on its illumination.

In this case a beam of light is projected across the stack, and its intensity when it reaches the selenium varies with the density of the smoke. Hence, if a plate of selenium of suitable structure is placed opposite to the source of projected light, its electrical resistance will vary with the density of the smoke, and by connecting the selenium plates in series with a suitable indicating meter to the source of electric-current supply, variations of smoke density will be made manifest by variations in the current flowing through the meter.

On a metal plate in the boiler room are installed the smoke-indicating meter and a potentiometer, the latter being provided with a slidable brush for adjusting the potential on the selenium plate and serving as a simple and effective means for setting the indicator on the "clear" indication, as when no smoke is issuing from the stack. The system is connected with the ship's lighting main at 125 volts. (Paper before the Annual Meeting of the Society of Naval Architects and Marine Engineers, November, 1916, from an abstract in the *International Marine Engineering*, vol. 21, no. 12, December 1916, p. 539. *d*)

Sawdust Firing at the Singer Plant at South Bend, Thomas Wilson

One of the large branch factories of the Singer Manufacturing Co. is located at South Bend, Ind. Here all cabinet work and stand-part operations are performed, from the raw material to the finished product. A large plant was required to supply these works with steam for heating, factory use and power purposes. There are three boiler plants with a total of 3016 boiler horsepower in 18 units, consisting mostly of small water-tube boilers provided with plain grates and arranged for burning coal and sawdust.

The most interesting feature of the plant is the system for burning the sawdust.

The sawdust is fed to the boiler furnaces independently of the coarser material. The collector system (Fig. 2) consists of four steel towers outside the machinery building. All the various trunk ducts are carried into these main towers, the suction being furnished by eight large motor-driven fans, two for each tower (the fans are driven by four 180-h.p. synchronous motors). Four small fan equipments in series, each somewhat larger than its predecessor, remove the sawdust which drops into the collectors and deliver it successfully from tower to tower until it is finally discharged into the collector located above the boiler room.

Upon leaving this latter collector the sawdust drops through chutes into a horizontal scraper or flight conveyor. Through gates in the conveyor bottom the sawdust drops into six steel tanks, one for each boiler. As soon as the first tank is filled, the gate may be closed or in any event the sawdust will automatically pass on and drop into the next opening. These tanks are on a level with the firing floor. They are oval at the top and flare out at the bottom so that there will be no difficulty from the sawdust arching and lodging in the upper part.

At the bottom of each tank are two friction-disk-driven screw conveyors which carry the sawdust over and drop it into the chutes on top of the boiler furnaces. Means are provided for individual adjustment of the rate of feed of each furnace.

The method here described obviates the danger of unevenness of the fuel supply and excess of either air or fuel and permits of accurately controlling both fuel and air.

Since the power plant has been installed, general conditions forced certain changes. It had been the plan to store the excess of sawdust in the summer months when the demand for fuel is low, and use the surplus to supplement the supply during the heating season. Various conditions have greatly reduced the output of waste available for use as fuel, and coal has to be used at times. When so used it is burned exclusively at night for supplying steam for the dry-kilns, pumps and lighting.

The original article reports data of tests of the boilers with sawdust fuel. It is of interest to note that with this fuel a superheat of 560 deg. fahr. is attained, an evaporation of 4.33 lb. of water per pound of fuel as fired, and an equivalent evaporation per pound of fuel from and at 212 deg. fahr. of 5.09 lb. of water. The efficiency of boiler and furnace combined, based on dry fuel, was found to be 64.9 per cent. (*Power*, vol. 44, no. 25, December 19, 1916, pp. 838-844, *d*)

A unique scheme is used in the design of the apparatus for controlling the high-duty elevator pumping engines at this plant, described in *Power*, vol. 44, no. 26, December 26, 1916, p. 874.

Hydraulics

A Theory of Fluid Friction, William Gatewood

An attempt to correlate the laws of fluid motion having a bearing on the subject of frictional resistance, and to formulate a theory.

This theory may be summarized as follows:

1 Frictional resistance per unit of surface varies as the square of the equivalent rubbing velocity determined by considering the flow to be laminar.

2 Friction between adjacent laminæ of the fluid varies as the rate of change of velocity occurring at their boundary.

3 In the case of a fixed body and a moving fluid, the frictional resistance experienced up to a given distance abaft the cutwater must be balanced by the loss of head in the wake at the same distance abaft the cutwater.

4 The width of the wake at a given distance abaft the cutwater and the reduction of velocity in the wake at various distances from the fixed body may be determined by the consideration that the loss of head outboard of any lamina is equal to the frictional resistance experienced by the lamina before reaching the given distance from the cutwater.

5 The determination of the loss of head in the wake is complicated by the condition that the volume of the fluid passing the fixed body is not altered, although the velocity in the wake is decreased. The consequent elevation of the surface of the fluid becomes of considerable importance when the velocity is relatively small or the reduction in velocity occurs quickly on account of roughness of surface.

6 The energy and action of the eddies may be assumed to be such that the loss of head may be determined as though the flow was entirely laminar. (Paper read before the Annual Meeting of the Society of Naval Architects and Marine Engineers, November 1916, abstracted from *International Marine Engineering*, vol. 21, no. 12, December 1916, pp. 543-544. *t*)

The Effect of Sudden Enlargement upon the Flow of Water in Pipes, T. J. Rodhouse

Paper describing experiments conducted for the purpose of determining the effect of sudden enlargement of section upon the flow of water in pipes. Coincidentally the action of the pitot tube has been studied under disturbed conditions of flow,

with a view to determining the conditions under which the tube may be relied upon to give accurate indications.

The paper describes the apparatus used. The investigations were limited to the two cases of the effect of sudden enlargement from pipes of 1 in. and $1\frac{1}{2}$ in. in diameter to one whose diameter is 2.096 in. The pipes were straight, smooth, seamless drawn brass tubing.

The pitot tube consisted of a straight cylindrical german-silver tube $\frac{1}{16}$ in. in diameter and projecting about $\frac{3}{32}$ in. from the end of a larger brass tube of $\frac{5}{16}$ in. external diameter by $\frac{7}{32}$ in. internal diameter having hose connections and a setting arm or pointer for indicating correctly the position of the impact opening when placed in the pipe. The tube had only a single impact opening $\frac{1}{32}$ in. in diameter located passes through a thumbnut set in the upper end of the frame. By turning the thumbnut the tube can be quickly and accurately set and firmly held at any desired position in the traverse. The author attributes the uniformity of readings in practically all of these traverses largely to this accurate means of controlling the position of the impact point. The impact opening was circular, $\frac{1}{32}$ in. in diameter, and in making a traverse the opening was kept pointing directly upstream, its axis always parallel to the axis of the pipe.

The writer suggests the following expression for the loss of head in feet due to sudden enlargement:

$$H_b = K\left(\frac{A_2}{A_1} - 1\right)^2 \frac{V_2^2}{2g}$$

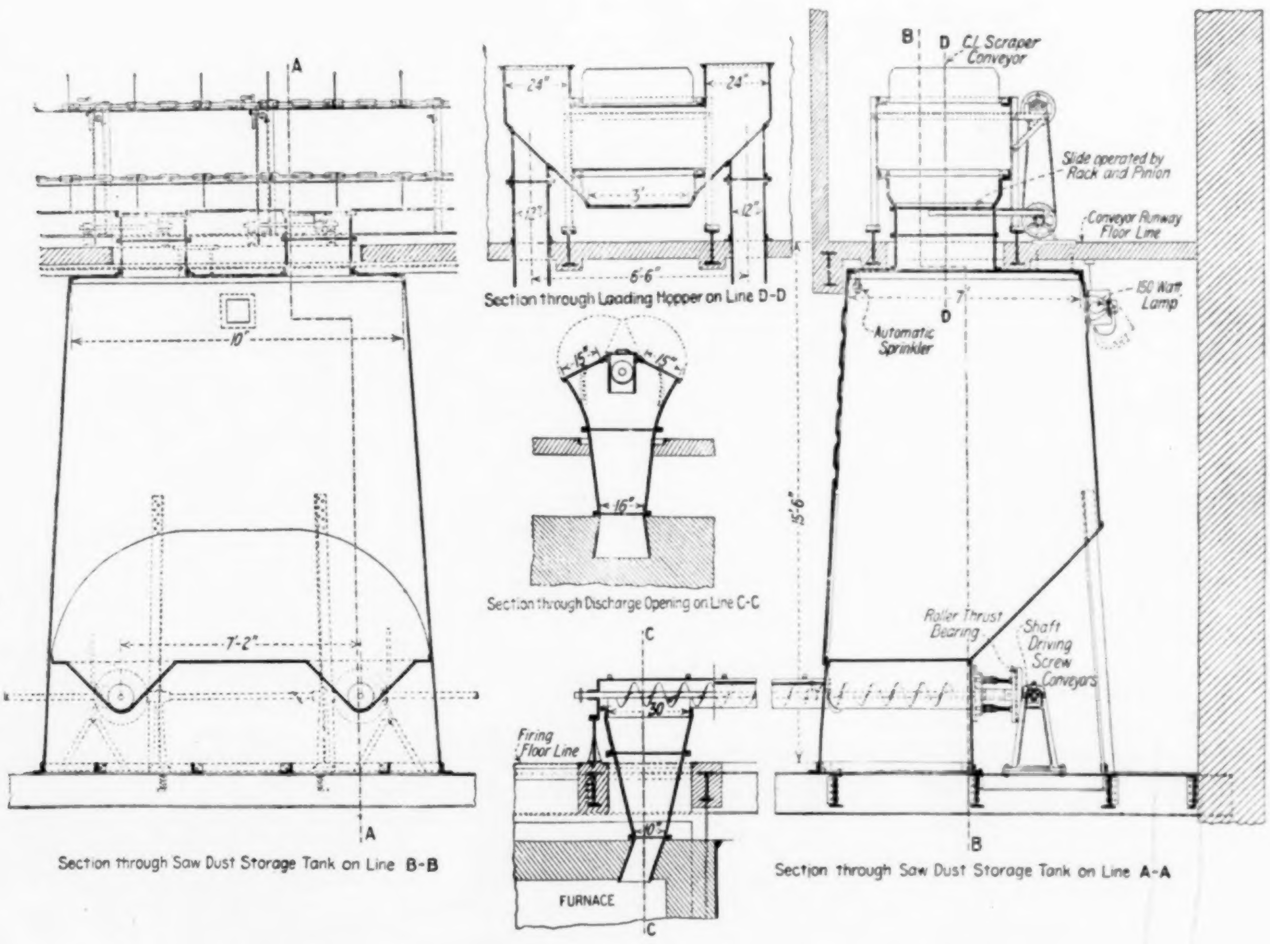


FIG. 2 SAWDUST-FIRING PLANT OF THE SINGER MANUFACTURING CO., SOUTH BEND, IND.

0.04 in. from the end, with its axis intersecting at right angles the axis of the tube. The static pressure was taken at the piezometer at the wall of the pipe in the same plane with the tube. The pressures from the impact opening and the static piezometer were conducted to the triple differential gage through $\frac{1}{4}$-in. heavy cotton-insertion rubber tubing.

An attachment invented by Prof. G. S. Williams for facilitating the setting of the tube was used. It consists of a brass frame whose base fits snugly over the stuffing box and is securely clamped there by three set screws. The frame is slotted on each side for guiding the central tube which receives the main stem of the pitot tube, holding it in place by a large thumbscrew. This central tube is threaded its full length and which is a constant, times the theoretical loss by Borda's formula. In this equation, A_2 and A_1 are the areas of the larger and smaller pipes. V_2 is the mean velocity in feet per second in the larger pipe (in the formula on p. 59, apparently by typographical error, V is used.—Ed.) and $g = 32.2$; K is a coefficient. Two tables are given in the article in which values of K are given. These tables show a slightly smaller loss of head as observed than the computed theoretical loss due to enlargement as expressed by Borda's formula. In the opinion of the writer, this discrepancy may be due to one or two causes, or perhaps to both. Either the frictional loss which enters into this equation is less than that which occurs in the case of the straight pipe with undisturbed flow, due perhaps to the cen-

ter of velocity of the jet as it enters the larger pipe and continues in this condition for some distance before spreading out and obtaining its full pressure and frictional effect on the wall of the pipe, or else the loss in the impact of the particles in the expanding jet due to the enlargement of the pipe section does not follow exactly the law for sudden enlargement as expressed in Borda's formula, failing to obey this law, perhaps, on account of conditions which might be considered as producing a water cone of gradual instead of sudden enlargement. The author prefers the latter theory as a possible explanation rather than the former, for it is difficult to imagine any reduction in frictional resistance less than that for straight pipe in the region of these greatly disturbed conditions.

As regards the pitot tube, the final results obtained in this investigation are summarized by the author in the following words:

1 The pitot tube measures with a fair degree of accuracy, always within two or three per cent and more frequently within one per cent, the velocities of flow in a pipe where the resultant motion of the water throughout the entire cross-section at the point where the tube is inserted is a forward motion, and where the distribution of velocities is symmetrical about the axis of the pipe.

2 The pitot tube is a means by which eddies or whirls caused by obstructions in the pipe may be detected, but it will not measure with any degree of accuracy the discharge of a pipe when inserted in the immediate region of such eddies.

3 The rating coefficient of discharge of the pitot tube for normal conditions cannot be applied in the case of abnormal conditions produced by sudden enlargement where eddies exist, but immediately below the region of eddies the rating coefficient of discharge may be applied with a fair degree of accuracy.

4 The eddies produced by sudden enlargement of section extend for the short distance of only about two or three diameters below the enlargement.

5 The disturbance caused by sudden enlargement of section produces abnormal conditions in the distribution of velocities which continue down the pipe for a distance of about 35 diameters.

6 The ratio of the mean velocity to the velocity at the center, $\frac{V_m}{V_c}$, increases in value, in the case of sudden enlargement, from a minimum near the point of enlargement to a maximum at a point about 11 diameters downstream, after which it begins to gradually decrease, approaching the value of the ratio for flow in straight pipe at a distance of 35 diameters below enlargement.

7 The pitot tube reversed, i. e., the impact point turned downstream, gives a negative pressure head, which reduced to velocity, negative, gives a value whose ratio with the velocity in the upstream direction is fairly constant for any given form of tube. But the relative values of the downstream readings to the upstream readings for different forms of tubes vary greatly. The maximum negative pressure or suction action at the impact point of the pitot tube occurs when the direction of the axis of the opening is approximately perpendicular to the direction of flow. (*The Cornell Civil Engineer*, vol. 25, no. 2, November 1916, pp. 49-61, 2 figs. *et*)

THE FLOW OF WATER IN WOOD-STAVE PIPE, **Fred C. Scobey**

A paper on the determination of capacity and on the design of wood-stave pipe, based both on the theoretical investigations and field tests.

The author offers a new set of formulæ based on experiments on round wood-stave pipe described in engineering literature and supplemented by an extensive set of experiments in which he was aided by Ernest C. Fortier. These formulæ are as follows:

$$H = \frac{7.68\,V^{1.8}}{d^{1.17}} = \frac{0.419\,V^{1.8}}{D^{1.17}} \ldots\ldots\ldots\ldots [1]$$

$$V = 1.62\,D^{0.65}\,H^{0.555} \ldots\ldots\ldots\ldots [2]$$

$$Q = 1.272\,D^{2.65}\,H^{0.555} \ldots\ldots\ldots\ldots [3]$$

where H is the head of elevation lost in overcoming internal resistances within a fairly straight pipe of uniform size per 1000 linear feet of pipe; V the mean velocity of the water during test in feet per second; D the mean inside diameter of the pipe in feet; d the mean inside diameter of the pipe in inches; and Q the mean discharge of the pipe during the test in second-feet.

The exponents of V and H in these formulæ are the same as those in the corresponding formula proposed by E. A. Moritz (*Engineering Record*, vol. 68, no. 24, p. 667). The difference in the formula is caused by the divergence in the intercept curves in the logarithmic diameter shown in the original article. As indicated in these curves, the difference becomes greater as the larger pipes are approached, for the reason that all data for large pipes in the Moritz formula came from his tests on the 55¾-in. Mabton pressure pipe.

The writer comes to the following conclusions:

1 That the new formula herein offered is the best now available for use in the design of wood-stave pipes, as its application meets (within one per cent) the mean of all observations and the mean capacity of all wood pipes upon which experiments have been made.

2 That a very conservative factor of safety should be used where a guaranteed capacity is to be attained.

3 That the Kutter modification of the Chézy formula is not well adapted to the design of wood-stave pipes.

4 That the data now existing do not show that the capacity of wood-stave pipe either increases or decreases with age. This statement of course does not consider sedimentation, a purely mechanical process.

5 That if silted waters are to be conveyed, the pipe should be designed for a working velocity of from five to ten feet per second.

6 That if sand is present in the water, the design should be for a velocity of about five feet per second, which will be high enough to carry out a large part of the sand and at the same time not so high as to seriously erode the pipe. The better method, of course, is to remove the sand by sumps or other means.

7 That air should be removed from the intake end of every pipe line, especially when the capacity load is approached.

8 That wood pipe will convey about 15 per cent more water than a ten-year-old cast-iron pipe or a new riveted pipe, and about 25 per cent more than a cast-iron pipe 20 years old or a riveted pipe ten years old. (*United States Department of Agriculture, Bulletin No. 376,* 96 pp., 7 figs. and several large plates, *etA*)

Internal-Combustion Engineering

AN AMERICAN OIL ENGINE, Frank C. Perkins

Description of a novel two-cycle two-cylinder oil engine developed at Milwaukee, Wis.

This oil engine works on the two-cycle Diesel principle,

and is characterized by the employment of a cylinder in which operate two working pistons opposite to each other, as shown in Fig. 3. Shortly before the upper working piston has reached its uppermost position, it uncovers the exhaust ports arranged along the whole circumference of the cylinder, at which time the burned gases from the previous working cycle pass through an exhaust manifold into the surrounding atmosphere.

Immediately after this the lower working piston uncovers its scavenging ports likewise arranged along the whole circumference of the cylinder, through which the scavenging air rushes in, driving out the remaining products of combustion and charging the cylinders with fresh cold air. The placing of the ports for the admission of scavenging air at the cool lower end of the cylinder allows cold air to be admitted and insures a more effective charge. During the following compression stroke of the two working pistons the charge is compressed to a temperature well above the ignition point of the fuel employed.

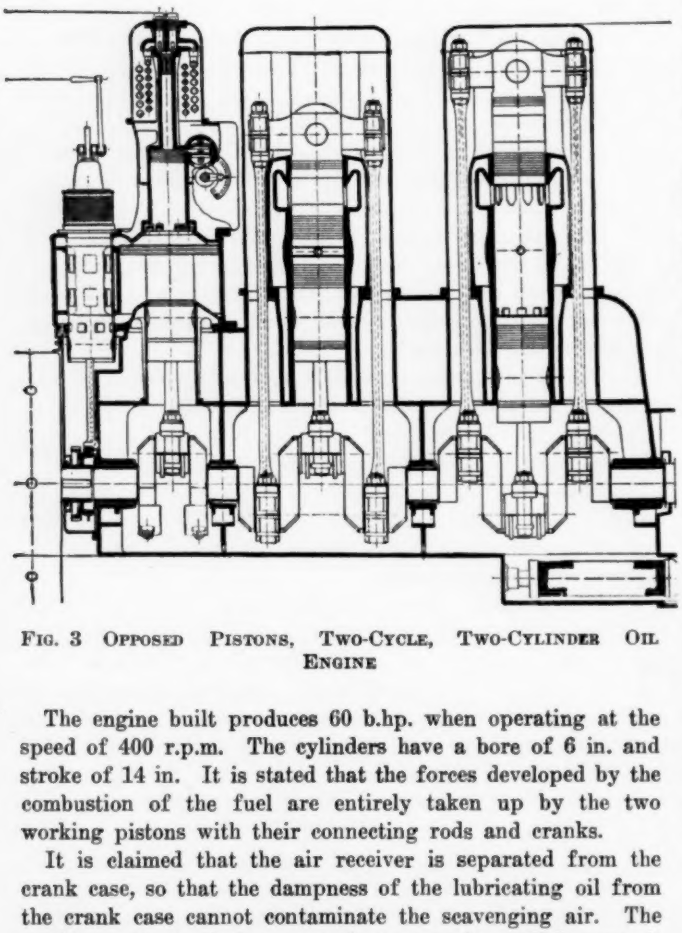


Fig. 3 Opposed Pistons, Two-Cycle, Two-Cylinder Oil Engine

The engine built produces 60 b.hp. when operating at the speed of 400 r.p.m. The cylinders have a bore of 6 in. and stroke of 14 in. It is stated that the forces developed by the combustion of the fuel are entirely taken up by the two working pistons with their connecting rods and cranks.

It is claimed that the air receiver is separated from the crank case, so that the dampness of the lubricating oil from the crank case cannot contaminate the scavenging air. The working output of the scavenging pump is small because it delivers the scavenging air to the receiver under a pressure of only 2 lb. per sq. in., which is entirely sufficient to clean the working cylinders of the burned gases. The compressed air for fuel injection is produced by a single-acting two-stage air compressor mounted in tandem over the scavenging pump, whose stepped piston is the extension of the piston from the scavenging pump. The air pressure in the injecting-air bottle delivered from the high-pressure stage should remain constant at about 1,000 lb. per sq. in. under the varying load of the engine. The compressor delivers a little more air than is required for fuel ignition, and this surplus, passing through a by-pass valve connected with the low-pressure stage of the compressor, is stored in the starting tank under a pressure of about 150 lb. per sq. in.

The valves on the compressor are of the automatic type. Special relief valves are fitted after every stage of the compressor to prevent excessive pressure in the air mains. The fuel pump is driven by means of helical gears direct from the crankshaft, and a separate plunger is provided for each working cylinder of the engine. The governor actuates the suction valve of the fuel pump in such a manner that the amount of fuel delivered to the working cylinders is in accordance with the load carried by the engine.

It is claimed that the combustion space between the two pistons, being a circular chamber without projections or recesses, constitutes the most efficient form of combustion chamber. The period of injection of the fuel into the working cylinder is variable in such a manner that the needle of the fuel-injecting valve remains open for a longer period when operating under a full load, and closes earlier when under a light load. This arrangement prevents the disturbance of combustion because the quantity of air needed for breaking up the fuel and injecting it into the combustion chamber is in accordance with the varying load of the engine. It reduces further the power output of the air compressor and gives the engine a high degree of speed variation.

The engine is started by means of compressed air at low pressure. By turning the starting lever the compressed air is admitted through a distributing valve to both sides of the piston of the scavenging pump, which now acts as an air motor and sets the engine in motion. It is stated that this engine can be started at a low air pressure of 150 lb. per sq. in., but the starting continues to be effective even should the pressure drop to 60 lb. per sq. in. The article also describes the forced-feed lubricator used on this engine. No data of tests are reported. (*The Isolated Plant*, vol. 8, no. 12, pp. 13-14, 2 figs., December 1916. *d*)

Diesel-Engine Construction in the United States

Up to a couple of years ago it cannot be said that there was any extensive production of Diesel engines in the United States, even though arrangements for it were being made. Since then, however, mainly because of the impetus given by the abnormal conditions in shipping, extensive developments have taken place. About a year ago three of the most important shipbuilding companies in the United States, having recognized that the large merchant motorship had come to stay, laid plans for the immediate and near future by securing constructional licenses from prominent European firms who had obtained practical success with high-powered marine Diesel-type oil engines.

Although Germany is the original home of the Diesel engine, they went for their designs not to that country but to Denmark and Holland, where greater strides have been made with the marine development. The William Cramp Ship and Engine Building Company secured a license from Burmeister & Wain, of Denmark; The New York Shipbuilding Company and the Newport News Shipbuilding & Dry Dock Co. licenses from the Werkspoor Company (Holland).

It is stated that no sooner had these firms concluded negotiations than they were overwhelmed with orders for steamships, which has somewhat delayed motorship building.

It is also stated that the shipbuilding yards controlled by interests connected with the Bethlehem Steel Company are now developing a Diesel-engine type under the supervision of engineers of that corporation.

In this connection, of considerable interest are data referring to a Diesel motorship designed by The New York Shipbuilding Company at Camden, N. J., to the order of an important American oil company.

She is a single-screw ship designed to carry oil in bulk, and is of the single-deck class with poop bridge and forecastle. Length overall, 260 ft.; breadth, 42.5 ft.; draft, 20 ft.; deadweight capacity, 3000 tons; indicated horsepower, 1360; speed loaded, 10 knots.

The engine is to be a six-cylinder, single-acting, four-cycle model of the Werkspoor pure-Diesel design. Cylinders, 22 in. bore by 39⅜ in. stroke; the total of 1360 i.hp. to be developed at 125 r.p.m.; mean effective pressure, about 100 lb. per sq. in.

The length of the engine overall will be 27 ft. 3 in., and height above shaft center, 16 ft. 9 in.; the net weight will be about 122 tons, while the total machinery weights are expected to be in the neighborhood of 220 tons. Auxiliaries will be steam-driven, and probably the exhaust gases from the main engine will partially be used for firing the donkey boiler, so as to economize on fuel.

An oil-fired or coal-burning steamer of the same dimensions and speed could not carry this amount of cargo and would, therefore, have a much lower earning power. In addition to this, the fuel bill of the motorship will be about one-fourth that of a steamer. Her tonnage bill will be less in proportion to cargo, and there will be no wages or food bill for stokers. Her oil-fuel bill for a 17-day voyage will be under $1000, this with oil at $1.50 per bbl.; but as she will take oil in Texas or Mexico, this cost will actually be reduced by 50 per cent. Hence it is expected that, as compared with a steamer of the same size, she will show high economic advantages. (*Motorship*, vol. 1, no. 8, December 1916, p 10, 1 fig. *dc*)

THE MOTIVE POWER OF THE M. S. DEUTSCHLAND, Russell Palmer

Description of the motive power of the merchant submarine *Deutschland* from data obtained from the officials of the company operating the vessel. The article is based upon a personal interview with Chief Engineer H. Kleis of the *Deutschland*, at New London, Conn., on November 6.

From data published in the article it appears that the engines are of the Krupp type and are built on the four-stroke cycle. Further, the well-known Krupp bronze construction is not used in this instance (it is stated that it has been retained only in the two-stroke-cycle motors which continue to be built), and steel and cast iron are employed instead.

According to the statement of the Chief Engineer, the submarine is fitted with two six-cylinder engines somewhat smaller than the regular Krupp submarine engine and somewhat simpler in construction.

As to dimensions, Mr. Kleis, in the first interview, stated that the cylinders have a bore of 45 cm. (17.35 in.) and a stroke of 60 cm. (23.4 in.). Subsequently, however, Mr. Kleis changed these dimensions to 40 cm. × 50 cm. He also stated that while these engines have a range of speed from 200 to 400 r.p.m., the ordinary operating speed is 380 r.p.m., i. e., not far from the maximum. Assuming that this maximum speed is correct, that would mean a piston speed of nearly 1600 ft. per min. and an output of almost 1300 b.hp., which, if true, is certainly remarkable. It seems, however, more likely that the ordinary operating speed is not 380, but 280 r.p.m. A stroke of 60 cm. would mean that the engine is 9 ft. high, which is, however, not impossible, as the submarine has a generous beam to give her the cargo-carrying capacity so essential in her work.

It is stated that a special adjustment to the fuel-injection valve permits it to be adjusted, when the engine is at a standstill, for each general range of speed, either high or low. Pressure in the cylinders at the moment of fuel injection is from 42 to 45 atmospheres. No trouble from cracked pistons or cylinders was experienced, even though, on the first round trip, the engines are stated to have turned over more than 11,000,000 times.

An illustration in the original article reproduces the only photograph ever made of the engine room of the submarine. That the engines are Krupp is shown by the beveled cylinder heads with fuel-injection valves set in on angle. This is a unique feature of the Krupp motor. It is also apparent from the double valve mechanism that these are four-cycle engines. As this photograph could not be reproduced for technical reasons, another illustration (Fig.4) is given, which the editor has been able to secure through the courtesy of Mr. Chas. H. Bedell, Electrical Engineer, Electric Boat Company, Groton, Conn. (*Motorship*, vol. 1, no. 8, December 1916, pp. 3-4, 1 fig. *d*)

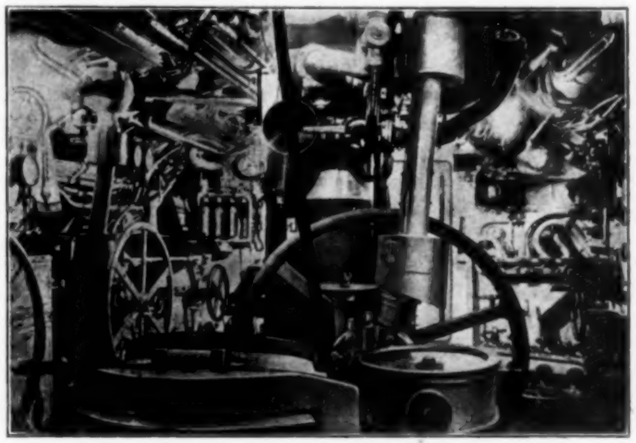


FIG. 4 CENTRAL CONTROL ROOM OF THE SUBMARINE "DEUTSCHLAND," DEPTH RUDDER TO THE LEFT

A STUDY OF OIL ENGINES IN IOWA POWER PLANTS, H. W. Wagner

Bulletin of the Iowa State College of Agriculture and Mechanic Arts.

The bulk of this Bulletin was written in the early part of 1915 and was based on data gathered before that time. During the interval between the writing and publication, many industrial and commercial changes have occurred, and in particular the price of fuels has changed and the cost of many materials of construction has become abnormal. The Bulletin, however, retains a considerable amount of interest. It covers the use in Iowa of oil engines, carburetion, semi-Diesel and pure-Diesel types, and presents a large amount of valuable statistical material.

It was planned by the Iowa Engineering Experiment Station to secure a list of oil engines in the State, to visit them, and to test some of them, the primary object of the tests being to secure fuel-consumption figures at various loads. For this reason only electric-light and power plants were chosen, as the current from the electric generator offered the most convenient reliable medium for measuring the power developed. Other related measurements were taken, however, such as quantity

of cooling water used, temperatures, indicator cards, and data necessary to calculate a fuel heat balance.

In general it was found that a high-compression or Diesel engine has better fuel economy than the medium-compression or semi-Diesel engine, which in its turn has better fuel economy than the low-compression or carburetion engine. The engine with higher compression not only consumes less fuel for a given output of power, but also burns a fuel which costs less per gallon; but its first cost is higher than that of a low-compression engine.

Tests on twelve engines of various makes and types showed a fuel consumption per estimated b.hp-hr. ranging from 2.95 to 0.55 pints. Reports of monthly operating records from seven of the most efficient oil-engine plants in the state show a range of from 2.60 to 1.03 pints of fuel oil per kw-hr. generated. Corresponding fuel costs ranged from 1.30 to 0.39 cents per kw-hr. The high figure is taken from a plant containing three carburetion engines with a total rating of 330 hp., burning distillate figured at 4 cents per gal. The low cost is from a plant containing a 225-hp. Diesel engine burning fuel oil figured at 3 cents per gal.

Fuel combustions during tests did not always average as good as guarantees submitted by manufacturers and agents for the same engines at the same loads. Most of these tests were made without any special preliminary adjustments.

Attendance labor is less in small plants when an oil engine instead of a steam engine is employed, and such is also likely to be the case for larger plants when coal is fired by hand. Lighting plants in many towns of about 500 or 600 population are operated by oil engines, and seem to be holding their own in a financial way. The cost of generating by steam under the same conditions might be almost prohibitive. For engines of over 225 hp. capacity, additional experience is necessary to determine whether best final economy is to be reached by Diesel or steam power.

As to reliability, it is stated that the present oil engine of any type is inherently less reliable than the steam engine or turbine, and more skill is required to keep the oil engine running smoothly. Recent installations indicate, however, that power engineers are gaining confidence in the reliability and general advantage of semi-Diesel and Diesel engines for small and medium-sized power plants.

Oil-engine lubrication has presented a perplexing problem in numerous cases. Proper characteristics required by individual engines and possessed by particular lubricants are not well enough known. Some oil engines are cooled by raw well water, which is then run into the waste. Other plants have installed a cooling tower or basin and use the same water over and over.

Practically all oil engines possess a tendency to knock or pound at times.

Difference of final costs with carburetion and semi-Diesel engines is less than might be expected. A lower price per gallon of fuel oil and a lower fuel consumption with the semi-Diesel are partly offset by the lower first cost of the carburetion engine and lower assumed rates of depreciation and repairs. These rates have been assumed on the basis of past performance. It seems likely that, in the future, such rates will be more nearly equal. Broader experience at both the manufacturing and operating ends is leading to better reliability and fuel economy in the semi-Diesel engine. Also increased production is likely to lower the first cost of the latter type. In the above calculations the price of fuel oil for the carburetion engine is assumed at four cents per gallon and that for the semi-Diesel at three cents. The difference is only one cent, but when it is more, as often occurs, the advantage in favor of the semi-Diesel will be increased accordingly.

The Bulletin contains cost figures of operation of various types of oil engines based upon prices existing during 1914 and 1915. A summary of these calculations is given in the following table:

Unit of Energy	Engine: Carburetion 50 hp.	Engine: Semi-Diesel 50 hp.	Engine: Diesel 120 hp.
Brake hp-hr.	2.91	2.75	1.72
Kw-hr. generated	6.60	6.28	3.50
Kw-hr. delivered to line	9.79	9.39	3.50
Kw-hr. delivered to consumers	14.83	14.34	5.78

Consideration of general operating factors, and the actions of manufacturers, then, point to greater future advantages of the semi-Diesel over the carburetion engine than would be indicated by figures in the above tabulation.

In noting the lower energy costs with the Diesel engine, it should be understood that they are due not only to better fuel economy but also to a larger unit and to a greater service demand which eliminates the necessity of a storage battery. (*Official Publication of Iowa State College of Agriculture and Mechanic Arts*, vol. 15, no. 10, August 20, 1916, Bulletin 42, Engineering Experiment Station, 159 pp., 55 figs, *ecs*)

PISTON AND SMALL-END LUBRICATION IN DIESEL ENGINES, George B. Vickers

Discussion of lubricating troubles in Diesel engines, which the speaker ascribed either to the use of unsuitable lubricating oil or to faulty design.

For Diesel-engine lubrication, pure mineral or hydrocarbon oils are the best, as they contain a much smaller percentage of acid than animal or vegetable oils. Many compound oils are good, but, although they may be carefully blended originally, there is sometimes evidence of disintegration under repeated use. They are also liable to give a gummy deposit. The best test of lubricating oil is on the air compressor. If the oil causes pitting on the compressor valves and shows an acid scouring action on the valves in the air-bottle beds, one may expect the main-cylinder-liner wear to be excessive. As to the amount of the latter, figures taken from a number of engines give a mean wear of 0.010 in. to 0.012 in. per 1000 hours run when the engine is heavily taxed. The lubrication requirements of the small ends and the pistons are contradictory. For pistons, an oil with a moderate viscosity of say 130 to 180 at 140 deg. fahr. gives good results, while an oil with a good viscosity of say 400 to 500 at 140 deg. fahr. is best for small-end lubrication.

For enclosed-type engines thicker oil is required than with the open type, as the temperature inside the crank case is much higher than on open-type engines.

In the works of Hick, Hargreaves & Co., Ltd., a number of naval high-speed engines were constructed and tested under load. With thin oil which had a viscosity of 110 at 140 deg. fahr., difficulty was experienced and the fuel consumption was high. Thicker oil having a viscosity of 140 at 140 deg. fahr. was then used, reducing the consumption from the minimum of 0.45 lb. per b.hp-hr. to 0.419 lb.

A lubricating oil used for pistons or small ends should not emulsify, so that if any water drops in the crank pit it can afterward be separated. When a different oil is used for top-end lubrication than is used for the piston, care should be taken that the oils will blend.

Filtered oil should not be used too often on the pistons, as its viscosity gets too low for this work.

The customary method of piston lubrication is through four or six stems or quills leading through the water jacket to the liner. Many engineers now insist on having a separate feed to each quill, that is, they have a six- or eight-feed lubricator fitted for each cylinder. It is costly but a good plan. Piston seizures have been caused by faulty arrangement of lubricating pipe and leaky back-pressure valves.

Trouble resulted also from improper arrangements of lubricating pumps. In the majority of cases they are driven from the crankshaft and so are placed much higher than the quill line. The result is after a short stoppage the feed pipe has been drained and the piston fails to receive any lubrication for a few minutes after starting. A good plan now adopted by one or two firms is to have the lubricators fixed well below the lubricating belt line and work off the indicator gear on the vertical shaft, thus insuring that the pipes are always charged. The pump should be fitted with a flushing arrangement in case of necessity, and preferably sight feeds with regulating valves. The check valve on the lubricator pipe should be well designed and periodically examined to make sure that there is no bituminous matter holding the valve up and interfering with the supply.

Trouble has been avoided (Mr. Lyle) by altering the piping so that the check valve was vertical and therefore assisted by gravity in keeping on its setting.

The method of securing the quills is sometimes a cause of trouble. Some makers prefer a tapered hole in the liner and provide the quill with a rounded nose: the quill is then screwed home tight over a tapped hole on the water jacket. When the parts get warm and expand, these quills have been found to act as struts and have caused piston seizures immediately opposite to the lubricating holes. An improved method is to have the quill screwed into the liner, a plain hole in the water jacket, and an external joint made. In England a telescopic quill is used.

Some makers have adopted instead of the quill method of lubrication one termed "splash system." With this system the pistons have skirts which protrude well beyond the lower edge of the liner at the bottom of the stroke. The piston relies on the splash from the bottom end of the connecting rod for its lubrication. It was found that this system is effective on pistons up to 14 or 15 in. in diameter, but quite unreliable on larger-type engines. Its chief trouble is that lubrication cannot be regulated, is very uncertain, and there is a tendency to wastage.

Top-End Lubrication. Phosphor-bronze bearings are usually adopted for the top-end bearings, and attempts to use white metal proved unsatisfactory. The wear on phosphor-bronze bearings is seldom more than 0.001 in. per year, while white-metal bearings may show more wear than this in one week. When a phosphor-bronze split bush is used, the average clearance is 0.003 in. vertically and 0.006 in. at each side. More clearance is required if the bush is solid, say 0.006 to 0.008 in. vertically and 0.008 in. at the sides.

The gudgeon pins should be fully case-hardened at the ends as well as on the bearing surface. A case occurred recently where the pin was left soft at the ends, and when tapping the pin into the piston the end of the pin was bulged, and when forced into the piston it split the boss in two places.

The position of the gudgeon pin in the piston is very important. If the pin is located too low, the piston will tend to heel over at the top when maximum compression pressure occurs; similarly, if the point is located too high, the piston will tend to heel over when the maximum working thrust occurs. A good long skirt is advisable to act as a guide and to reduce the pressure per unit area due to thrust. The length of guiding surface on the piston should be 1.4 to 1.6 times the diameter for slow-speed engines, but may be reduced to 1.2 times the diameter for high-speed engines.

The writer proceeds to describe the methods for lubricating the top-end bearings: viz., the scraper system, the banjo system, and the one using one or two slots in the piston which pass over the leads from the oil-supply pipes and hose leading from the bottom of the slots through the piston to the center hole in the gudgeon pin. If this latter method is used, it is preferable to have two slots in the piston, one midway between crankshaft center line and cross center line on the front side of the piston, and one directly opposite, so that whichever side of the liner the piston is thrust against, one of the slots is able to scrape the maximum quantity of oil from the liner. The slot is best when V-shaped in section, and the top and bottom should be undercut at about 45 deg., the scraping edges being left moderately sharp. A sluice should also be cut to connect the top of the slot and a circular scraper groove cut in the piston to take advantage of the oil scraped off the walls by this groove. The slot should be fairly long, but a moderate head of oil should be allowed between the bottom of the slot and the top of the gudgeon pin. The oil hole should have a large countersink both in the piston and also where it enters the pin. The hole in the center of the pin should be at least $1\frac{1}{4}$ in. in diameter for a 6-in. pin, as it acts as a reservoir for the oil. Two holes at least should be drilled from the top of the pin to the center, one close to each end of the bearing surface: these holes may be drilled at 30 deg. to vertical center line. Both these holes should lead into a longitudinal groove on the top surface of the pin. These grooves should have well-rounded edges to assist the oil to escape.

A system of forced lubrication on all of the bearings effectively solves the problem of top-end piston lubrication, but has its disadvantages, as it is thought likely that the piston will receive too much lubrication. The oil is thrown from the bottom-end bearings on to the liner walls, and when the piston is on its suction stroke the slight pressure in the crank chamber tends to force the oil past the relaxed rings, the result being that the lubricating oil is burned, and very peaky indicator cards are obtained, showing a maximum pressure frequently of from 100 lb. to 150 lb. above compression pressure. The high consumption of lubricating oil has retarded the progress of the enclosed type of engine. These difficulties have been overcome, first, by guarding the bottom-end bearings to avoid splash on to liners; second, by preventing the oil from creeping from top-end bearings along the gudgeon-pin keyway on to piston surface; third, by providing scraper grooves on pistons with return ducts to inside; fourth, by dissipating the vapor in crank chamber, this vapor tending to pass the rings on the suction stroke.

The speaker objected to the common method of withdrawing the oil vapor in the crank chamber, which is to take the air-compressor suction or the main-cylinder suction from the chamber. He believes that this causes dirty valves, is wasteful, and in a few cases has proved dangerous. He found that the vapor is most effectually withdrawn by a belt-driven extraction fan; the gases are led to a baffle box, where they are condensed, thus recovering the oil which by other methods is burned.

In the discussion which followed, it was pointed out that when the sulphur content of the fuel oil reaches a certain limit, the sulphur reacts on the lubricating oil, especially if compounded with vegetable oils, and causes a sticky deposit

analogous to vulcanized bitumen, which destroys the lubricating properties of the oil. (Paper read before the Diesel Engine Users' Association; abstracted from *The Mechanical Engineer*, vol. 38, no. 985, December 8, 1916, pp. 439-441. *gp*)

HEAT-BALANCE TESTS OF AUTOMOBILE ENGINES, Prof. Walter T. Fishleigh and W. E. Lay

The authors show how a demand for better performance and economy and the ever-increasing cost of volatile fuels have emphasized the necessity for thorough engineering work in the successful automobile manufacturing plant.

The paper is based on a comprehensive test of an automobile engine enclosed in a hood similar to that used on the car in normal service, an air blast being directed through this hood of speeds approximating those at which the engine would dri 'e a car with a given gear ratio.

The results from the heat-balance tests at the three operating speeds of 640 r.p.m., 1000 r.p.m. and 1350 r.p.m are shown in Fig. 5. These curves show that the heat that goes into brake horsepower ranges from 8.6 to 19 per cent, and increases at any one speed as the load is increased. The highest value is found for the greatest load taken at the lowest speed. At 6.25 hp. output, which is about necessary on a good level road for propelling the car at 18 m.p.h., the thermal efficiency of the engine based upon brake horsepower is 10 per cent. This means that when an owner uses in his engine $1.00 worth of gasoline, he develops at the flywheel and delivers to the transmission box just ten cents' worth of power. Where the other ninety cents go is indicated by the relatively long ordinates of the other curves.

Heat loss to the cooling water was practically constant at 600 r.p.m. and was about 40 per cent. At the two higher speeds it decreased with increased output.

The percentage of heat dissipated to the cooling air appeared variable at the low speed, while at 1000 and 1350 r.p.m. there was evident a slight decrease with increased output. The heat loss in the exhaust at 640 r.p.m. varied regularly from 26.6 per cent at low output to 18.6 per cent at 20 hp. At the two higher speeds it was relatively much larger with slight increase in output. It appears, therefore, that the trend of exhaust-gas losses is contrary to that of losses to the cooling water.

The fuel consumption per unit horsepower per unit of time at any speed was high at low horsepower output and decreased steadily as maximum output at any speed was approached. Thermal efficiency correspondingly increased at any speed as the output increased. Under maximum output conditions, which constitute an infrequent and unimportant automobile operating range, fuel consumption is relatively low and thermal efficiency relatively high.

Mechanical efficiency at any speed improves with increased load.

The complete heat balance for one run was found to be as follows:

	B.t.u.	Per Cent
Input	368,000	100.00
Output (b.hp.)	50,560	13.74
Cooling water	113,750	30.90
Cooling air	60,600	16.47
Exhaust	139,632	37.94
Total	364,542	99.05
Heat unaccounted for		0.95

The paper describes in detail the methods and apparatus used.

As regards the fields for future developments, the writer believes that probably overcooling at low speed and output, where ample capacity is provided for all extreme demands, has already received some attention, but important improvements can be brought about from an entirely different direction. Alloy metals can be developed that will stand a far higher average operating temperature. The present metal construction can be entirely replaced by a built-up alloy-metal construction that will need no cooling system, or, at best, only an air draft. Porcelain or other heat-resisting substances can be utilized for part or all of the combustion chamber, and better lubricants

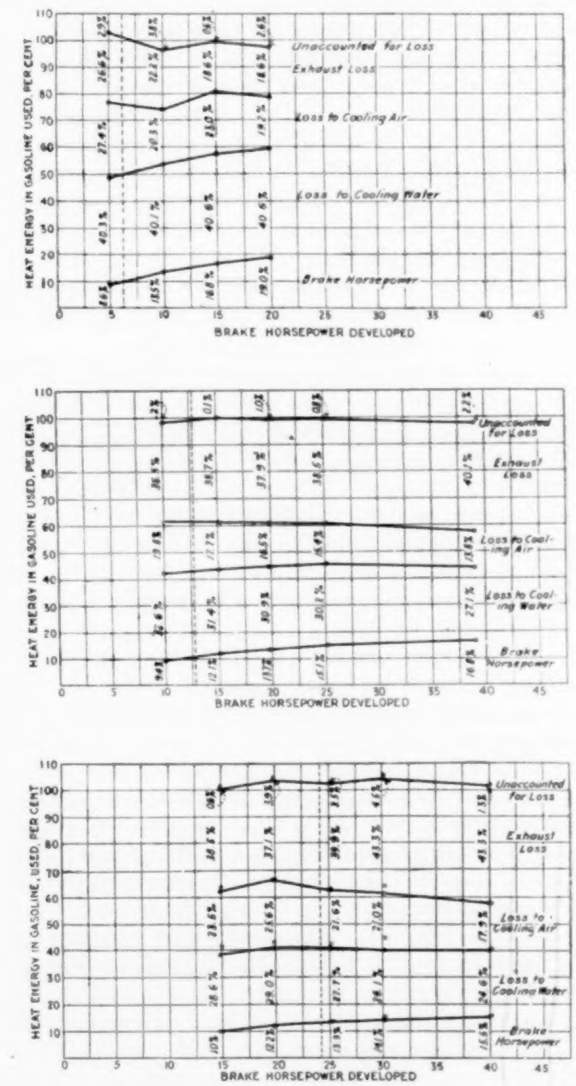


FIG. 5 RESULTS OF HEAT-BALANCE TESTS OF AUTOMOBILE ENGINES AT VARIOUS SPEEDS

are possible. But a fascinating ideal is always a type of engine in which the same wall does not serve as a part of a high-temperature combustion chamber and at the same time as a lubricated surface upon which the most important high-speed reciprocating mass must prevail and have its bearing. Under present limitations higher thermal efficiency might be had by the use of a cooling liquid whose boiling point is higher than that of the conventional water.

The reduced efficiency and increased fuel consumption under normal light loads at any speed are deserving of the most serious attention. The internal-combustion engine op-

erating upon the present Otto cycle is not well adapted to efficient operation upon partly opened throttle, and the author suggests as promising fields of research larger valves or ports and more of them, variable timing of the valves so as to insure fairly uniform compression, higher compressions with direct fuel injection as in the Diesel or semi-Diesel engine, and the constant-pressure cycle. *(S. A. E. Bulletin,* vol. 11, no. 3, December 1916, pp. 271-287, 8 figs., *eA)*

Measuring Apparatus and Measurements

STANDARD SUBSTANCES FOR THE CALIBRATION OF VISCOMETERS, Eugene C. Bingham and Richard F. Jackson

For the purpose of the calibration of viscometers there is a need for one or more liquids of viscosity greater than water which can be easily obtained in pure condition and whose viscosity is known with a considerable degree of certainty. The substances selected, besides water, were mixtures of ethyl alcohol and water, and sucrose and water. Previous work upon water and alcohol was adequate and consequently the experiments were confined to the sucrose and water. The sucrose was purified by repeated recrystallization from water solution and contained residual impurities of the order of one-thousandth of a per cent. The solutions used in the measurement were analyzed by determination of density and by polariscopic test.

The viscometer used in the investigation consisted essentially of a U-tube fitted with a capillary on one limb surmounted by a bulb with constrictions which could be used to measure the volume of liquid. A bulb of similar size and shape was sealed on the other limb. The viscometer was connected to a manometer and pressure apparatus for the application of pressure. From the observations the viscosity was calculated by the usual formula

$$\eta = Cpt - C' \rho / t$$

by measuring the time of flow of pure water at 20 deg. cent. and substituting its viscosity 0.01005.

The viscosity was measured at a variety of applied pressures. To obtain the true effective pressure, the height of liquid in the manometer is corrected for air buoyancy, column of connecting air, and hydrostatic head of the liquid undergoing measurement. In order to be certain that the drainage of solution was complete, the time of flow required to discharge and to fill the bulb was measured. Furthermore, viscosity was found to be independent of applied pressure. To test calculations and corrections the viscosities of water were measured, using a considerable range of pressures. The value was found to be constant.

In order to avoid the arbitrary scales of commercial viscometers and the inconvenient magnitudes of the absolute units, we suggest the use of the "centipoise" as a unit of viscosity. This is one-hundredth part of the C.G.S. absolute unit. The centipoise is almost exactly the viscosity of water at 20 deg. cent. (1.005), and hence is at the same time the specific viscosity of any substance referred to water at very nearly 20 deg. cent.

The viscosities of water have been determined by several investigators. The existing data have been reviewed in order to correct them so far as possible according to our present knowledge. The mean values expressed as fluidities may be expressed by the formula

$$\varphi = 2.1482 \left\{ (t - 8.435) + \sqrt{8078.4 + (t - 8.435^2)} \right\} - 120$$

in which φ is fluidity and t centigrade temperature.

Mixtures of ethyl alcohol and water may be used as standards. Their fluidities expressed as functions of temperature and weight and volume percentage of alcohol accompany the complete article.

The viscosities of a 39.99 per cent sucrose solution were measured at temperatures varying from 0 deg. cent. to 95 deg. cent. The observed values correspond to the formula

$$t = 0.597\,(\varphi + 20) - \frac{1438.6}{\varphi + 20} + 38.24$$

Inasmuch as some discrepancy was found to exist between this and former values, the experiment was repeated and practically the same values were obtained.

The measurements were then made on 20.007 per cent and 59.96 per cent sucrose solutions. The fluidities at the latter concentration corresponded to the formula

$$t = 1.472\,(\varphi + 5) - \frac{323.2}{\varphi + 5} + 58.62$$

The values found in the present investigation indicated a higher viscosity than those of previous investigators. (Abstract of *Scientific Paper* no. 298, Bureau of Standards)

MEASUREMENT OF FLOW OF UNPURIFIED GASES AT HIGH TEMPERATURES BY MEANS OF PITOT TUBES, J. M. Spitzglass

During the past year experiments were conducted at the Pitney Court Station of the People's Gas Light & Coke Company of Chicago, on measuring the volume of gas flowing from an individual generator. The device employed, shown in Fig. 6, consisted of a special pitot tube inserted in the flow of gas, connected to a differential gage indicating the pressure difference created by the flow.

As can be seen from the figure, there are here two points available for measuring the flow of gas from the superheater before the gas enters a common main. One is at the outlet from the superheater before the gas enters the washbox, where the average temperature of the flowing gas is about 1200 deg. fahr., and the other is at the outlet from the washbox, where the temperature varies between 180 and 190 deg. fahr., but where there is a possibility of excessive moisture to be entrained from the washbox, the distance from the latter being very short in this case.

As a rule there is now little difficulty in determining the volumes of flowing gases from the velocity pressure developed by the impact of the flow; and the relation between the two physical quantities, velocity and pressure, is well known for ordinary temperatures. But where gases are flowing at high temperatures this relation becomes more or less complicated, as the impact of the flowing mass creating the pressure difference is a complex quantity equivalent to the weight of the flowing mass times the square of the velocity, and the change in the force of the impact may be due to a change in the velocity of the flowing mass or a change in the density of the gas, or to both.

The installations as made proved that the flow of hot gas could be measured in this way and that the high temperature of the gas did not apparently affect the tube or interfere with the indications of the gage. It was found, however, that the tube could not be operated continuously on account of the carbon accumulating and covering the small openings through which the differential pressure is transmitted to the velocity gage. This carbon deposit was found to consist of a layer of lampblack mainly on the side from the flow.

An attempt was made to blow out the tubes with steam with-

out removing them from the gas main, but in many cases it was found necessary to remove them and clean them out mechanically.

Various arrangements of tubes were used with somewhat different results in the flow tests. The one which worked apparently better than other shapes had the ends cut off to a 60-deg. angle from the horizontal.

The results of the tests are presented in charts and tables. One table appended to the article gives the general properties of dry air from 0 to 212 deg. fahr. and also the pressure and density of saturated water vapor. A second table gives the properties and correction factor of saturated gases. This correction factor is independent of the specific gravity of the gas and can be used directly for correcting the volumes of saturated gases at the given temperatures between 0 and 212 deg. fahr. at 30 in. absolute pressure. Other tables give the factors prepared for determining the ratio of the density of atmospheric air at the given temperatures and of gases from 0.75 to 0.40 specific gravity to the density of dry air at 60 deg. fahr. temperature and 30 in. absolute pressure. This "specific ratio" is substituted for the specific gravity of the gas in computing the volume of the flow.

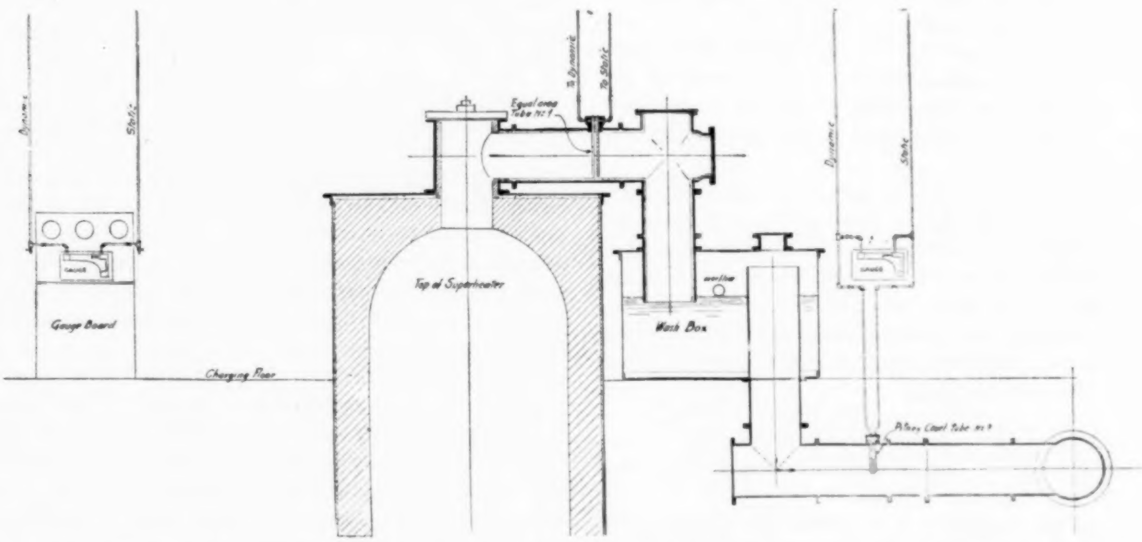


Fig. 6 Installation for Measuring the Flow of Unpurified Gases at High Temperatures by Means of Pitot Tubes

For the purpose of computing the flow of saturated gases, the writer gives the following equation:

$$Q = 21.7Cd^2\sqrt{\frac{H}{S}}$$

where Q is the quantity of gas in cubic feet per minute flowing through the pipe at the given temperature and pressure; d = diameter of the pipe in inches; C = a numerical coëfficient depending upon the shape of the pitot tube used; H = differential head in inches of water; and S = specific gravity of the gas as referred to air. A numerical example of the application of the formula is given.

The article recommends a method of procedure for the computation of the flow of gases. Among other things is fully covered the question of the use of the correction factor. The tables may be utilized also for other purposes, such as determination of the carrying capacity of pipes for saturated gases and of conditions of partial saturation. (*American Gas Engineering Journal,* vol. 106, no. 1 (whole no. 3069), January 1, 1917, pp. 5-10, 3 figs., *et*)

Mechanics

Remarks on Dynamics of the Automobile, N. W. Akimoff

Discussion of the fundamental principles of a theory of spring suspension, with a brief consideration of the dynamics of spring damping, kinematic features of harmonic motion, energy consumption, and shock absorbers.

The oscillation of a spring will necessarily be a damped one and will have a tendency to die out after a certain interval of time. This damping is due partly to external friction, but also to a considerable extent to some sort of internal, molecular action. Certain properties of damping oscillations are, however, often lost sight of. If the friction is constant the amplitude of motion decreases but the period remains unchanged. If the damping is proportional to velocity then the period is only slightly increased, but so little that here, too, it can be considered unaffected while the amplitude decreased.

This refers to so-called free vibration of a spring, but a spring subject to any periodic action, for example, actuated by some sort of a connection with an unbalanced engine, will vibrate precisely at the rate of the latter. This constitutes what is known as forced vibration, which the spring quickly converts into a free vibration of its own natural period as soon as it is freed from the influence of the periodic forces. All this, however, holds good only for such cases as that of a spring arranged vertically and supporting a weight, but this formula can under no circumstances be applied to a case of a body rocking about one end and spring-supported on the other. This might induce an error as great as 100 per cent or more, and an entirely new formula would have to be derived.

The writer vigorously objects to applying the plain pendulum formula to cases of automobile suspension involving rolling or pitching.

From the kinematics of vibrating motion can be found under what conditions the passenger will be thrown from a seat vibrating according to a plain pendulum law.

From this the author proceeds to a statement of his objection to frictional shock absorbers. The objection appears to be that in climbing up a bump, the action of the spring is retarded, thus throwing a certain amount of extra load on the tire and spring, already overloaded owing to the upward impulse due to the obstacle. In allowing the compressed spring

to come gently to its normal position, the absorber performs its useful work provided the action is not delayed too much. When the wheel drops into a pocket or depression, the reverse conditions are present. The absorber retards the descent of the wheel and does its best work in restoring the wheel to its normal position, although here, too, the action should not be delayed too much. It is evident that these actions are contradictory. What one would like to have is an absorber that is inert when the wheel goes over a bump and active in coming down, also inert when the wheel goes down into a hole and active in restoring it to its normal position; but it does not appear possible for any absorber to answer these requirements.

The author believes that the fight between the champions and the antagonists of absorbers is progressing on altogether wrong grounds.

The analysis of the elemental suspension system is carried out by means of an imaginary elemental car consisting of one wheel provided with a pneumatic tire, a platform representing the unsprung weight, a spring above it and over the spring another platform, which is the sprung weight. In such a system there will be two independent modes of vibration. One mode will comprise simultaneous oscillations of both weights possessing the *same period*, both moving up or down at the same time. The second natural mode will be such that both weights move in opposite directions although with the same period, but through a much shorter amplitude than before. Neither the short nor the long period is the same as it would be if the sprung weight alone vibrated on its spring. This shows the inadequacy of the pendulum formula if directly applied to the problem of natural oscillations of the car even when simplified in the above way.

The automobile can vibrate in a number of different ways, the main modes of oscillation being plunging, rolling and pitching. The problems of vibrations in automobiles can be solved by Lagrange's equations and, for example, for pitching the author proposes the following formula:

$$\text{Period} = T_p = 2\pi\,(\sqrt{\delta/g}\,\sqrt{2k^2/l^2})$$

where δ is the initial (static) deflection of each spring under its load; $g = 32.2$; k is the radius of gyration about the center of oscillation; and l the wheelbase. From this formula the author comes to the conclusion that the wheelbase should be kept as short as possible because the period is inversely proportional to its length. From this point of view, the writer believes that if the cantilever arrangement of springs gives better riding qualities, the reason lies in the fact that the spring is fastened more closely to the center of the body, thus giving the same effect as would reduce wheel base, i.e., a slower period of pitching.

The distribution of the weight appears to be of importance, as is evidenced by the radius of gyration k, to which the period is directly proportional. In other words, to secure easy riding (slow period of pitching) the loads should be placed as far as possible from the center of the car. The mere fact that they give the same deflection does not in itself preclude the possibility of entirely different effects due to load distribution. (*S. A. E. Bulletin*, vol. 11, no. 3, December 1916, pp. 262-270, 5 figs, *t*)

Railroad Engineering

Locomotive-Axle Failure and Its Causes

Abstract from the report of the Chief of the Division of Safety, Interstate Commerce Commission, covering the investigation of an accident which occurred near Hoffman, Ill., when an axle failed under a freight engine of the Southern Railroad.

The investigation showed the presence of an area of metal at the surface of the journal which contained chatter marks and short incipient cracks made by the roughing cut in the machining of the forging from which the axle was made.

It was further found that the axle was made from an untreated solid-steel forging and was finished turned throughout its length.

In addition to the discussion of this particular instance, the report touches on some matters of general interest.

Heavy machine-tool cuts tear the metal and also introduce internal strains. There is a close resemblance in the effect of such heavy tool cuts to shearing and punching effects if, indeed, they are not of the same order. Shearing and punching of steel are very properly prohibited in certain specifications, and it is also important that equivalent effects be avoided.

A further possibility of incipient fractures is introduced by the operation of quenching, with spontaneous rupture taking place. In fact, certain specifications with this in view require a shock test to be made of heat-treated axles to detect whether interior fractures have not been made by this process. The final state of internal strain in quenched axles which have had their temper drawn will be of lesser magnitude than the temporary state of strain which prevailed at the time of quenching.

The report emphasizes the necessity of securing workmanship of a high order in the machine finishing and fitting of material which is exposed to such situations as those which are occupied by axles, that is, repeated alternate stresses of tension and compression. While the magnitude of the stresses in the service of axles is somewhat indeterminate, there is no doubt that on some occasions very high fiber stresses are reached. Under these circumstances stresses which are incident to surface conditions should not be augmented by internal strains of fabrication, if they are found to be detrimental.

It has been customary apparently to consider only those stresses in axles which were due to the external loads coming from the weight of the engine or cars, as the case may be. But internal strains at the time of quenching—those which result from heavy machine cuts in rough turning and those which accompany the operation of cold rolling on journals for finishing purposes—appear to attain a magnitude comparable to the direct stresses which are caused by the wheel loads. It is true that such internal strains are mostly those having a tangential direction, while the failures of axles commonly occur by tension in a longitudinal direction, but coincident surface strains of compression have been found to exist in the quenched metal in both tangential and longitudinal directions. (*Iron Trade Review*, vol. 59, no. 26, December 28, 1916, pp. 1309-1312, 7 figs. *dp*)

Steam Engineering

Erosive Effect of Steam on Turbine-Blading Material, Lieut. (J. G.) T. J. Keleher, U. S. N.

In the summer course of the Post-Graduate Department of the Naval Academy an investigation of the erosive effect of steam on turbine-blading material was taken up as a research problem.

The apparatus used was a brass box 9 in. x 9 in x 7 in., which acted as exhaust chamber and contained the brass blading holders and blades, which were stationary and placed at

an angle of 10 deg. to the nozzles in order to avoid the spattering effect. On the front of the box was a steam chest containing expanding nozzles designed for 100 lb. gage pressure and 27 in. vacuum.

Extruded brass, rolled brass, rolled cupro-nickel, monel metal, Parsons metal, and drop-forged steel were tested. The tests were preliminary in their nature and will be followed next summer by tests at different steam velocities and with varying qualities of steam and degrees of superheat.

The results are shown in the form of photographs and a table of weight losses. From this table it appears that extruded brass stood up best in the 3400-ft.-per-sec. velocity with steam quality of about 87 per cent. Here the loss was 0.121. Monel metal followed with 0.273 and steel with 0.386.

Because of difficulty in obtaining the blading material there were dissimilarities in the dimensions of the pieces tested, particularly in the case of the steel specimens. These discrepancies in blading width and thickness vitiate weight losses when determined as percentages of the original weights of the specimens. In the case of steel, its width was less, and its thickness considerably less, than that of the other materials.

Rolled brass, cupro-nickel and Parsons metal did not compare at all favorably with the others. In general, there appears to have been no particular uniformity in the amount of erosion during the different periods.

On the photographs (which were taken at about 2 diameters after 3½ hours) can be seen the saw edges of the rolled brass and monel metal, and in particular the long points of the cupro-nickel which, it would appear, are the results of lack of uniformity in the structure of the metal. Steel appears also to begin to develop a similar edge. (*Journal of the American Society of Naval Engineers*, vol. 28, no. 4, pp. 836-838. and 2 pp. of photographs, *e*)

Operation of Curtis Steam Turbines and Alquist Reduction Gears in the Propulsion of Cargo Ships, W. J. Davis, Jr.

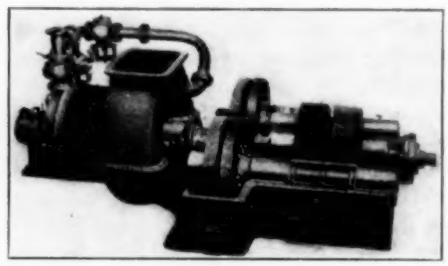
The first commercially successful steam-turbine-driven freighter, the S. S. *Vespasian,* built in England and equipped with a 1000-hp. Parsons turbine with reduction gear, was placed in service in 1909, but it was not until November, 1915, that the first American-built turbine freighter was commissioned.

The first cargo ship built in the United States and equipped with the new drive was the S. S. *Pacific.* This ship was built by the Union Iron Works Company at San Francisco, and propelled by a 2400-hp. Curtis turbine with Alquist flexible gears manufactured at the Schenectady works of the General Electric Company.

The use of the steam turbine in stationary plants resulted in extraordinary reductions in cost of power generation. The writer is familiar with a case where eight 1500-kw. reciprocating engines were replaced by a 12,000-kw. turbo-generator. Whereas it required twenty-four boilers to supply steam for the engines, eleven of these boilers were sufficient to enable the turbine to carry the same load.

It has been well known for a long time that any attempt to drive a ship propeller directly from a steam turbine must result in a compromise in which the efficiency of both turbine and propeller must be sacrificed. In the case of very-high-speed ships, such as destroyers and certain classes of passenger vessels, where certain advantages in the way of increased speed, reduction in vibration and saving in weight overbalance the failure to give the best attainable economy in fuel, it has been possible to make such a compromise. But this would not apply to slow-speed freight-carrying vessels because of limitations of propeller speed.

Take, for example, a freighter or tanker of 8000 to 10,000 tons capacity, with a speed, loaded, of 11 knots. Such a ship will require about 2500 hp. to drive it. The most economical speed for the propeller would be about 90 r.p.m., while that for the turbine would be not less than 3000 r.p.m. The difference is here so great that any attempt to drive the propeller direct would result in an arrangement so greatly inferior in economy to a reciprocating-engine drive as to outweigh any other possible advantage. The use of speed-reducing means between the turbine and propeller becomes, therefore, imperative if turbine drive is to be employed at all. The Alquist flexible gear as manufactured by the General Electric Company is one of the means of high-speed reduction. The wheels for this type of gear are made up of rolled-steel plates or disks rigidly bolted together near the center and keyed to the shaft. Each disk is reduced in thickness between the hub and rim sufficiently to give a small amount of flexibility in an



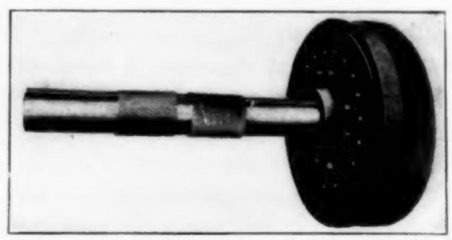


Fig. 7 Top Cut: Upper Half of the Alquist Gear with Gear Casing Removed; Bottom Cut: Intermediate Shaft of Reduction Gear

axial direction, and to permit this movement a clearance of about ten thousandths of an inch is provided between the disks at their rims. As the gears are of the double-helical type, this construction insures equal distribution of pressure along the face of the teeth. If the pressure applied by a pinion tooth at any point should exceed the normal pressure, the axial component will cause a slight axial flexure of the disk. Experience has shown that changes in alignment or slight inaccuracies in tooth cutting or assembling of the gears, which would cause objectionable noise, loss in efficiency, high temperature, and excessive wear on the teeth of solid gears, have little effect on the operation of the flexible-disk type.

Accurate measurements of the teeth of the Alquist reduction gears on the S. S. *Pacific* show the wear of the flexible-gear teeth to be almost negligible.

An interesting commercial feature of the present abnormal production of steel cargo vessels in this country is the uniformity in capacity, speed, and power requirements. Fully 90 per cent of the turbine ships completed or under construction by the Pacific Coast yards are provided with turbines

of the same type and practically of the same size, viz., 2400 to 2600 hp.

In practically all cases the ahead turbine is designed to run at 3380 r.p.m. It is of the Curtis type of impulse turbine and consists of five stages, the first having two rows of buckets mounted on a single wheel, and each of the succeeding stages a single row of buckets. The speed of the turbine is controlled by means of a lever-operated balanced throttle valve in the main steam line, but in order to overcome the loss of efficiency due to throttling when running at reduced speed, two hand valves are provided which block off a number of the first-stage nozzle sections. By this means it is possible to obtain 58, 75, 83 and 100 per cent of full power with full-speed pressure at the nozzles, resulting in a net saving of 3 per cent to 5 per cent in fuel when it is necessary to run the ship at reduced speed in a rough sea.

The astern turbine has two stages of similar construction but of smaller diameter, and is mounted on the same shaft and in the same casing as the ahead turbine, both having a common exhaust. When the ship is running forward, the wheels of the astern turbine revolve in a vacuum and therefore consume but little power.

The speed of the propeller being 90 r.p.m. and that of the turbine 3380 r.p.m., it is necessary to obtain a gear reduction of 37.5. This is accomplished by means of a double reduction, the high-speed gear having a ratio of 7.36 and the low-speed, 5.10. The reduction gear is of the "one-plane" type, i.e., axes of the high- and low-speed pinion and gear shafts lie in the same horizontal plane. This arrangement reduces the head room, simplifies lubrication, and facilitates inspection and accessibility of all parts.

Power is transmitted through the high-speed or driving pinion to two gears, one on each side, and thence through the two low-speed pinions to the low-speed gear. Rigid bearings are used throughout for the gears and pinions. Fig. 7 shows the intermediate shaft of the reduction gear, while Fig. 2 shows the gears with the top half of gear casing removed.

On the score of simplicity it is highly desirable to be able to use the same grade of oil for both the turbine bearings and the reduction gear, thus preventing the duplication of oil pumps, strainers, coolers, storage tanks, settling tanks, etc. It has been possible to accomplish this by the use of a moderate tooth angle and by reason of the flexible-disk construction of the gears. Several grades of oil were tried out on the S. S. *Davanger*, the best results being obtained with a medium-heavy oil having a viscosity of 260 (Saybolt) at 100 deg. fahr., which proved to be right for the dual purpose for which it was used.

The article gives detailed data as to dimensions and fuel consumption of tank steamers *Los Angeles* and *La Brea*. These ships differ from each other only in the character of the propelling machinery and the cargo-pumping systems. The *Los Angeles* is driven by a triple-expansion engine with a propeller speed of 65 r.p.m., and has the usual type of centralized steam pumping plant for discharging her cargo of oil. The propelling machinery of *La Brea* consists of a 2600-b.hp. Curtis turbine with Alquist reduction gear giving 90 revolutions at the propeller. She is fitted with a unique cargo-pumping system originated by O. B. Kibele, Superintendent of Transportation of the Union Oil Company, in which a separate electric-motor-driven pump is provided for each compartment, power being supplied to the motors from a 300-kw. 60-cycle alternating-current Curtis turbo-generator located in the engine room.

Although the average speed of *La Brea* is ½ knot better than that of the reciprocating-engine-propelled *Los Angeles*, it has been found that the increase in fuel consumption of the latter over that of the steam-turbine ship under operating

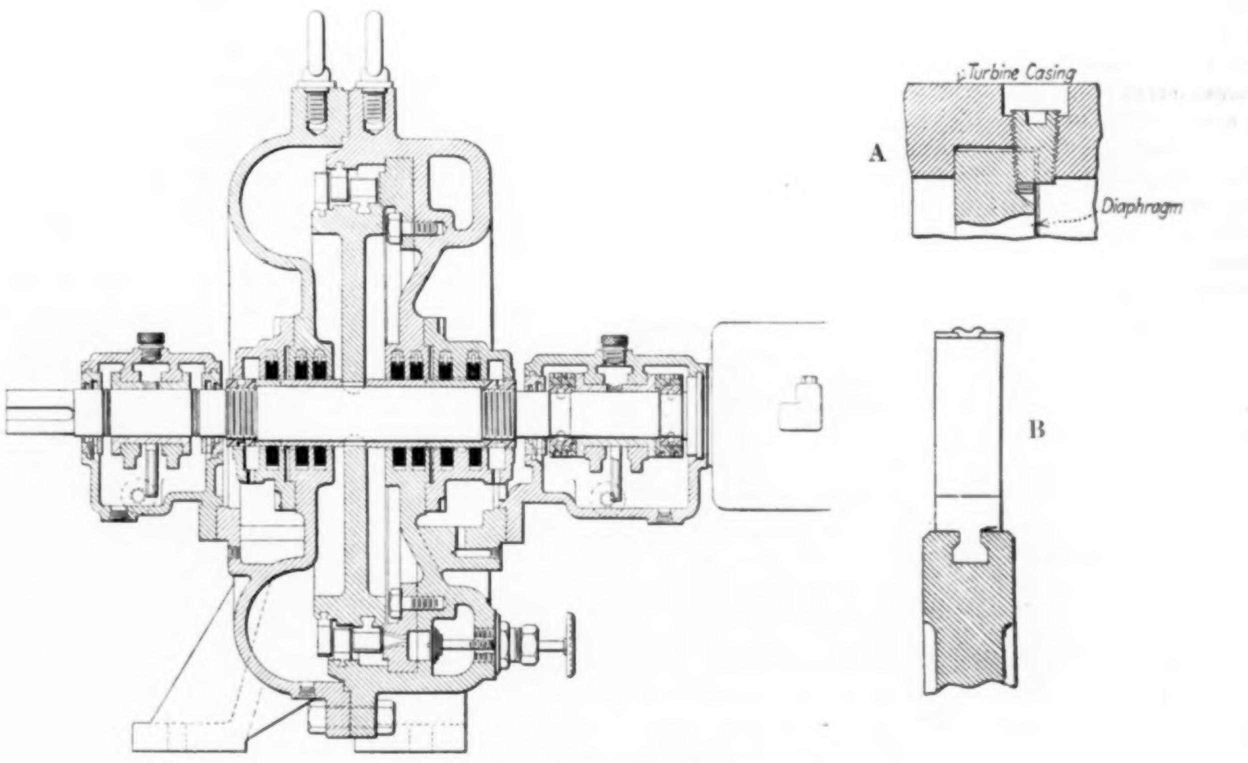


Fig. 8 Moore Steam Turbine

conditions is

While steaming..................17.9 per cent
While steaming and in port......21.1 per cent

With further improvements in the way of increased steam pressures, higher superheats, and power-plant design and equipment, there are still further possibilities in reducing operating costs of steamships driven by geared turbines. (*General Electric Review*, vol. 20, no. 1, January 1917, pp. 57-62, 4 figs. *de*)

The Moore Steam Turbines

Description of steam turbines manufactured by the Moore Steam Turbine Corporation, of Wellsville, New York, a newcomer in this line of production.

The company will manufacture a single-stage machine and a multi-stage turbine. The single-stage machine consists of a single-velocity stage made up of a set of diverging expanding nozzles and a wheel carrying two rows of moving blades with a set of stationary reversing blades following the first row of moving blades. The builders will limit the speed of the larger machines to 3600 r.p.m. and of the smaller ones to 5000 r.p.m. as a maximum.

The multi-stage turbine consists of the same single-velocity stage followed by two or more single-pressure stages, each of the stages consisting of a set of nozzles and a wheel.

In both types of turbine the casings are divided both vertically and horizontally, which allows of lifting the casing without breaking the steam or exhaust connections.

The diaphragms (Fig. 8A) are halved and are held in the casing by a set of special tapered screwed plugs inserted in the vertical joints while the diaphragm and casings are held in a fixture (as a rule in turbine construction dowel pins are used instead of screwed plugs).

The wheels and shaft are of steel and the first-stage wheel is of built-up or solid-forged construction. The wheels of the single stage are machined from solid steel plates. The buckets are of drawn steel and dovetailed into the periphery of the wheel as shown in Fig. 8B. The clearance over the bucket is about one-half inch and the endwise clearance is liberal, with the further provision that the side of the wheel and not the bucket will rub should the rotor become displaced in an endwise direction. (*Power*, vol. 44, no. 25, December 19, 1916, pp. 848-849, 7 figs, *d*)

Willans Line for Steam Turbines

With throttle-governed steam turbines, Willans' law that the total steam consumption plotted against output gives nearly a straight line is followed with very considerable accuracy.

The writer has drawn the Willans line for the 5000-kw. Rateau turbine at the London County Council Power Station from data taken from the paper read by K. Baumann before the Institution of Electrical Engineers in 1911, but used in plotting brake kilowatts and not the power developed at the switchboard. The four points plotted in the diagram, Fig. 9, lie very fairly in a straight line which, if prolonged, cuts the horizontal axis at *B*. It has frequently been assumed that the distance *OB* measured on the kilowatt scale represents the power required to drive the turbine light, and that the slope of the line *BA* is proportional to the blading efficiency of the turbine. The author shows that neither of these suppositions is correct and states further some interesting deductions made from a study of the Willans line of a turbine.

A turbine differs from a reciprocating engine in that by far the larger proportion of its wastes of energy, which are due mainly to windage, leakage losses and fluid friction, are proportional to the load. The resistance and losses which are independent of the load are only those due to the bearings, thrust block, the oil pump and governor drive, and to the glands. If water glands are used, as in the turbine under consideration, the gland losses are represented by the power absorbed by these glands, while if steam-packed glands are used, the loss is represented by the supply of steam necessary to prevent the entrance of air through the glands into the condenser.

The writer calculates these constant losses and shows that this can be done with fair accuracy.

Adding together all of the resistance, he gets a total of 89 hp. or, say, 66 kw., which is only about one-sixth of the distance represented by *OB* in the diagram, which scales 450

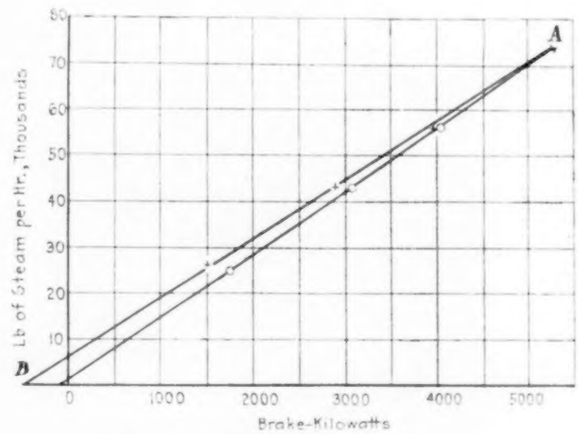


Fig. 9 Willans Line for Steam Turbines

kw. This wide discrepancy is due to the fact that the Willans line *BA* is not a line of constant indicated efficiency. The indicated efficiency of a turbine varies with the ratio of expansion, and, in many cases, particularly with reaction turbines which (for commercial reasons) have hitherto been run much below the most economical speed, the indicated efficiency at first increases as the load is reduced, afterwards diminishing again somewhat rapidly. It is however possible, to a fair degree of accuracy, to deduce from the actual Willans line a line corresponding to a constant indicated efficiency by making use of the proposition, which is very approximately true, that when a turbine is throttle-governed the indicated efficiency depends solely on the ratio of initial and final pressures. This proposition is necessarily true with a perfect gas, and even though steam is not a perfect gas, the rule holds with considerable accuracy throughout a large range of output.

The data from which the diagram was plotted are as follows:

Output of Turbine, B.kw.	Total Steam per Hour, Lb.	Ratio of Initial to Final Pressure
5347	73,930	228
4000	56,070	185
2885	42,630	123
1449	25,070	74

Of the total resistances of the turbine those due to fan action, leakage and the like are substantially proportional to the load. The fixed resistances have been estimated above as

66 kw., so that the gross output corresponding to the total torque developed at full load will be $5347 + 66 = 5413$ kw. Calling this the gross kilowatts the steam consumption per gross kilowatt is 13.66 lb. By the foregoing rule the consumption per gross kilowatt will be the same at all powers, provided the ratio of the initial and final pressures is the same. At the lowest load tabulated above, the initial pressure was 56 lb. absolute and the back pressure 1.55 in. of mercury. To get the same gross efficiency this back pressure should have been approximately $\frac{74}{228} 1.55 = 0.68$ in. of mercury, and in that case the output would have been $\frac{25\,070}{13.66} = 1836$ gross kilowatts, or $1836 - 66 = 1770$ b.kw.

This value has been plotted as a round dot in the diagram, and the other observations have been similarly reduced. The corrected Willans line thus obtained cuts the axis at a point scaling about 70 kw., and thus passes very approximately through the estimated value of the bearing, gland, and other fixed losses.

Thus, with the Willans line as ordinarily plotted, the heat available per pound of steam passed falls off as the load diminishes. Hence less work is done per pound of steam and the line at low loads is raised accordingly. The Willans line adjusted as above can be used to estimate approximately the increase in consumption at full load due to reduction in vacuum, and the writer shows that a diminution of vacuum from 28.51 in. to 27.23 in. would reduce the gross output from 5413 to 5100 gross kw., or to 5034 b.kw. Hence such a decrease of vacuum would increase the steam consumption per b.kw.-hour by about 6 per cent. (*Engineering*, vol. 102, no. 2657, December 1, 1916, p. 521, 1 fig. *t*)

Society of Automotive Engineers

The Society of Automotive Engineers is our youngest national technical society. Into it are fused the varied and yet similar and sympathetic interests of the automobile engineer, the aeronautic engineer, the motor-boat engineer and the agricultural-tractor engineeer. The parent of this organization is the Society of Automobile Engineers, which has been in existence since 1905. Because of the fact that its members are engaged in making very similar products, and because of the tremendous wealth of this one industry, the society has found itself in a unique position to practically enforce coöperation in a technical sense amongst its members.

The outstanding feature that differentiates the S.A.E. from other societies is the stress laid upon standardization. Under the initial guidance of Howard E. Coffin, great progress has been made in the elimination of unnecessary and wasteful variations in unimportant design.

The work that had already been done in the standardization of screw threads was not allowed to stop, but has been carried to a point where lock washers, sizes of steel tubing, steel specifications, fine-thread bolts and nuts, spark plugs, tire bases, magneto fastenings, and so on, have had their important dimensions standardized. This information has been disseminated to all automobile manufacturers and engineers, with the result that considerable labor, time and expense are saved in design by the ability to use what might be called staple dimensions.

The Winter Meeting of the Society of Automobile Engineers, at which the change was made to the Society of Automotive Engineers, was held in the Engineering Societies Building, January 9, 10 and 11, and the following additional standards were discussed, and in the majority of cases approved:

Direction of engine rotation for aeronautic engines
Thrust bearings
Mounting of starting and lighting equipment
Size of storage-battery jars
Hand starting cranks
Size of poppet valves
V-belts for fans
Steering-wheel-hub dimensions
Nomenclature
Car performance test
Spring-rebound-clip dimensions
Pneumatic-tire rims

A sum of $14,000 has been appropriated for the coming year for the work of the Standards Committees, and provided the committees do not run away too strongly with the standards idea, this money will be well spent. There is a tendency to standardize many things which are yet in a transition state, but this is an evil which can easily be overcome, and is indeed usually overcome in itself.

The Standards Committees are usually formed of the chief engineers of the leading companies interested, and one of the features, not the least important, is the opportunity of discussing in an informal way the various problems common to all. This is of material help in advancing the industry and has tended to promote a wonderful feeling of *esprit de corps* and coöperation amongst automobile engineers.

The professional session of the meeting occurred on the afternoon of January 11, at which the following papers were scheduled to be read:

Some Problems in Airplane Construction, Capt. V. E. Clark, Capt. T. F. Dodd, and O. E. Strahlmann
The Ultimate Type of Tractor Engine, H. L. Horning
Dynamic Balancing of Rotating Parts, F. Hymans
Remarks on Dynamics of the Automobile, N. W. Akimoff
Some Essential Features of High-Speed Engines, A. F. Milbrath
Heat-Balance Tests of Automobile Engines, Walter T. Fishleigh and Walter E. Lay
Aerial Navigation over Water, Elmer A. Sperry.

This session was opened by the presentation of a series of unusual stereopticon and motion pictures taken on the various war fronts in Russia, with brief explanations by Capt. V. E. Clark, U.S.A. Aeroplanes, hydro-aeroplanes and captive balloons were illustrated. An interesting feature of the aeroplanes was that, contrary to the general belief in this country, rotary-type motors seem to be very widely used. One of the slides bore the significant statement that 20,000 aeroplanes are used on the French front.

Captain Clark made a statement that the War Department welcomes and seeks the collaboration of the engineers in the development of its technical problems in general and those concerning aeronautics in particular.

Mr. Horning presented orally a general survey of the tractor engine situation. He emphasized very strongly the fact that a tractor engine must be primarily built so that it will run, and those parts which may require renewal or replacement should be designed in such a manner that whenever possible they can be replaced by some makeshift available on a farm.

As a rule the tractor is used in places away from well-equipped machine shops and has to do work which cannot

be delayed. Hence the design of a part may often be influenced quite as much by the possibility of replacement as by considerations of efficiency. As an example of selection on such grounds of expediency rather than engineering efficiency, the speaker mentioned the case of a V-belt to drive a fan. It is more efficient than the flat belt, but the farmer may be unable to find it in the local store when needed in a hurry. The flat belt can be easily manufactured out of an old piece of harness, and is therefore used in preference.

The solution of the kerosene-engine problem, in the opinion of the speaker, lay in the better-heated intake manifold, and such an arrangement that the heat be increased as much as possible at low speed and reduced at high speed.

Because of lack of time some of the papers were read by title only.

American Association for Advancement of Science

At the meeting of the American Association for the Advancement of Science and the affiliated national scientific societies held in New York City during the last week of the past year, there was a registration in the neighborhood of 2100. The Association met in twelve sections. There were fifty-six separate societies in session, including the four national engineering societies, which held one general meeting with the Association at the Engineering Societies Building. Dr. Henry M. Howe of Columbia University, chairman of the section, presided, and Dr. Bion J. Arnold, the retiring Vice-President and Past-President of the American Institute of Electrical Engineers, gave an address, which was followed by addresses by Mr. Clemens Herschel, President of the American Institute of Civil Engineers, and Dr. Ira N. Hollis, President of The American Society of Mechanical Engineers.

The fundamental idea which was apparently in the minds of the speakers at the meeting of the Association for the Advancement of Science in the Engineering Building, was to properly express the relation of what is commonly known as pure science to engineering as an expression of the so-called applied science.

Dr. Ira N. Hollis, President of the American Society of Mechanical Engineers, expressed on behalf of the engineering profession the most hearty wishes for the continued influence and success of the American Association for the Advancement of Science.

He stated that he had been associated intimately with teachers of science for many years and had never seen one of them engaged in research through which he did not hope to render service either by actually discovering something useful to man or by giving him a true reverence for the Almighty's works, and the last was sorely needed in the present times. Indeed, the speaker stated that if he had to choose he would prefer the rush light with the love of God and his neighbor to the finest electric light with materialism. "We men of science have made the external world what it is, and now we have a most imperative duty not in one or two societies but on the part of all of us, teachers, leaders in science and engineering, to exorcise the Frankenstein that is now trampling the life out of Europe.

"There is no pure science because no man knows the whole truth. . . . We can classify and group related phenomena and we can devise formulæ to express a great range of observation, but they are imperfect and must always remain so. The great function of this Association is something more than a clearing house for science. It must break down the fences that divide science into town lots, and should be freely supported by every engineer and every engineering society.

"It has been proposed that the National Academy and the engineers form some kind of an alliance for research. That would be good, but is not this Association the natural meeting ground for all scientists, and ought not national research to be conducted under the advice of all that the Association can supply?"

The speaker carefully emphasized that there was no distinction between what was called pure science and what was sometimes called applied science. When Theodore Richards was devoting his life to weighing the elements he was accomplishing more for the world than could be found by all the combinations of aniline dyes. In enlarging man's conception of the universe and in supplying him with tools to study it the better, his work was preëminent.

SELECTED TITLES OF IMPORTANT ENGINEERING ARTICLES

AERONAUTICS

Possible Improvements in Carrying Capacity and Speed of Rigid Airships, C. Dornier, Count von Zeppelin's Engineer. Aviation and Aeronautical Engineering, vol. 1, no. 10, December 15, 1916, 4 pp., 4 figs.

Enemy Aircraft Engines. The Automobile Engineer, vol. 6, no. 97, December 1916, pp. 350-357, 19 figs.

† Some Problems in Airplane Construction, Capt. V. E. Clark, Capt. T. F. Dodd, and O. E. Strahlmann. S.A.E. Bulletin, vol. 11, no. 3, December 1916, pp. 213-236, 15 figs.

Method of Obtaining True Angles of Wiring Plates for Aeroplanes, Seaplanes and Airships. Aeronautics, vol. 11, no. 165, December 13, 1916, pp. 386-388, 11 figs.

How Steel is Used in Aeroplanes, W. S. Doxsey. The Iron Trade Review, vol. 60, no. 1, January 4, 1917, pp. 97-100, illustrated.

The Sturtevant Model 5A, 140 HP. Aeronautical Engine. Aerial Age, vol. 4, no. 17, January 8, 1917, pp. 434-435, illustrated.

A Method of Aligning Single-Engined Tractor Biplanes, Byron Q. Jones. Aviation and Aeronautical Engineering, vol. 1, no. 2, January 1, 1917, pp. 358-359, 1 fig.

Les Biplans allemands, L. V. G. Jean Lagorgette. L'Aérophile, vol. 24, nos. 21-22, November 1, 15, 1916, pp. 326-340, 45 figs. German L. V. G. biplanes.

L' "Aviatik," Jean Lagorgette. L'Aérophile, vol. 24, nos. 19-20, October 1, 15, 1916, 15 pp., 50 figs.

† Abstracted in the Engineering Survey in this issue.

AIR MACHINERY

A Machineless Air Compressor. Power, vol. 44, no. 26, December 26, 1916, 3 pp., 5 figs.

AUTOMOBILES AND TRACTORS

Suggests a New Testing Method, Daniel Roesch. The Automobile, vol. 35, no. 25, December 21, 1916, 4 pp., 9 figs.

Russian Motor Car Requirements. Railway Gazette, vol. 25, no. 23, December 8, 1916, 2 pp.

The Modern Farm Tractor, Joseph Jandasek. The Gas Engine, vol. 19, no. 1, January 1917, pp. 1-8, 9 figs.
See also Internal-Combustion Engineering; Mechanics.

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The Heat Treatment of Steel, D. K. Bullens. Technology Club of Philadelphia. Proceedings of the Engineers' Club of Philadelphia, vol. 33, no. 145, December, 1916, 1 p.

†Identifying Light-Gray Inclusions, Geo. F. Comstock. The Iron Trade Review, vol. 59, no. 24, December 14, 1916, 3 pp., 17 figs.

Practical Handling of Iowa Clays, with Application of Ceramic Principles, Homer F. Staley and Milton F. Beecher. Official Publication of Iowa State College of Agriculture and Mechanic Arts, Bulletin 43, Engineering Experiment Station, vol. 15, no. 15, 48 pp.

Failure of Brass 2.—Effect of Corrosion on the Ductility and Strength of Brass, Paul D. Merica. Department of Commerce, Technologic Papers of the Bureau of Standards, no. 83, November 14, 1916, 6 pp., 3 figs.

Failure of Brass 3.—Initial Stress Produced by the Burning in of Manganese Bronze, Paul D. Merica. Department of Commerce, Technologic Papers of the Bureau of Standards, no. 84, November 17, 1916, 8 pp., 5 figs.

The Plastic Elongation of Wire, A. V. DeForest. The Iron Trade Review, vol. 59, no. 26, December 28, 1916, pp. 1305-1307, 4 figs.

†Notes on the Heat Treatment of High-Speed Steel Tools, A. E. Bellis and T. W. Hardy. Bulletin of the American Institute of Mining Engineers, no. 121, January, 1917, pp. 61-68, illustrated.

Modifications de la Dilatabilité de l'Invar par des Actions Méchaniques ou Thermiques, Ch. Ed. Guillaume. Comptes Rendus des Séances de l'Académie des Sciences, vol. 165, no. 22, November 27, 1916, pp. 654-658.
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Timber Protection Methods on the Santa Fe. Railway Age Gazette, vol. 62, no. 1, January 5, 1917, pp. 7-11, illustrated.
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Cast Iron for Engine Cylinders. The Engineer, vol. 122, no. 3182, December 22, 1916, pp. 549-550.

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EVAPORATORS

The Prache and Bouillon Evaporating Plants. Engineering, vol. 102, no. 2661, p. 637-640, 8 figs.

FIRING

Essential Characteristics of Mechanical Stokers, C. F. Herington. Steam, vol. 18, no. 6, December, 1916, 3 pp., 3 figs.

Mechanical Firing of Locomotives, W. S. Bartholomew. St. Louis Railway Club, vol. 21, no. 7, November 10, 1916, 49 pp., illustrated.

HYDRAULICS

Effect of Channel on Stream Flow, Nathan C. Grover. Journal of the Boston Society of Civil Engineers, vol. 3, no. 9, November, 1916, 12 pp., 6 figs.
See also Pipes and Piping.

†The Effect of Sudden Enlargement Upon the Flow of Water in Pipes, T. J. Rodhouse. The Cornell Civil Engineer, vol. 25, no. 2, November, 1916, pp., 49-61, 3 figs.

Freezing of Water in Subaqueous Mains Laid in Salt Water and in Mains and Services Laid on Land, William Whitlock Brush. Journal of the American Water Works Association, vol. 3, no. 4, December, 1916, pp. 962-980.

†The Flow of Water in Wood-Stave Pipe, Fred C. Scobey. United States Department of Agriculture, Bulletin 376, November 25, 1916, pp. 1-96, illustrated.

INTERNAL-COMBUSTION ENGINEERING

†Heat-Balance Tests of Automobile Engines, Prof. Walter T. Fishleigh and W. E. Lay. S.A.E. Bulletin, vol. 11, no. 3, December, 1916, pp. 271-287, 8 figs.

Tests of a Modern Touring-Car Engine, G. L. Guillet. Mechanical Engineer, vol. 38, no. 985, December 8, 1916, 2 pp., 2 figs.

Vapors for Heat Engines, William D. Ennis. Stevens Indicator, vol. 33, no. 4, October, 1916, pp. 318-331, 2 figs.

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†A Study of Oil Engines in Iowa Power Plants, H. G. Wagner. Official Publication of Iowa State College of Agriculture and Mechanic Arts, Bulletin 42, Engineering Experiment Station, vol. 15, no. 10, 157 pp., illustrated.

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Diesel Engine Construction in Philadelphia. Motorship, vol. 1, no. 8, December, 1916, pp. 8-9, illustrated.

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Spark Ignition, J. D. Morgan. Engineering, vol. 102, no. 2653, November 3, 1916, 1 p.

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MACHINE PARTS

†Friction Clutches, William G. Gass. The Mechanical Engineer, vol. 38, no. 980, November 3, 1916, 3½ pp.

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Internal Spur Gearing, Reginald Trautschold, Machinery, vol. 23, no. 5, January, 1917, pp. 405-409, 7 figs.

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Variable Speed Gears for Motor Road Vehicles, Robert E. Phillips. The Engineer, vol. 122, no. 3182, December 22, 1916, pp. 560-563, 1 fig.

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MACHINE SHOP

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Lubrication of Cutting Tools, Edward K. Hammond. Machinery, vol. 23, no. 5, January 1917, pp. 373-391, 42 figs.

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MACHINE TOOLS

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Determinazione dell'altezze per mezzo dell'altimetro, Mario Tenani. Rivista di Aeronautica, vol. 11, nos. 3, 4, May to July, 1916, 3¾ pp., 1 fig.
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Formola per il Calcolo delle Altitudini, Luigi Mina. Rivista di Aeronautica, vol. 11, no. 3-4, May to July 1916, 3¾ pp.
Formula for determining altitudes.

Planimeter Theory, G. B. Upton. The Sibley Journal of Engineering, vol. 31, no. 3, December 1916, 4 pp., 2 figs.

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Measuring Gases by a Standard Orifice, Thos. G. Estep, Jr. The Blast Furnace and Steel Plant, vol. 5, no. 1, January 1917, pp. 16-18, 2 figs.

†Points Out Advantages to be Derived in Regulating Operations of Water Gas Sets by Measuring Flow of Gases at Super-heater Outlet. American Gas Engineering Journal, vol. 106, no. 1, January 1, 1917, pp. 5-10, illustrated.
J. M. Spitzglass describes tests made with pitot tubes in measuring flow of unpurified gases at high temperatures at Pitney Court Station of People's Gas Light and Coke Company.

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†Remarks on Dynamics of the Automobile, N. W. Akimoff. S.A.E. Bulletin, vol. 11, no. 3, December 1916, pp. 262-270, 5 figs.

†Dynamic Balancing of Rotating Parts, F. Hymans. S.A.E. Bulletin, vol. 11, no. 3, December 1916, pp. 237-261, 19 figs.

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Making the 13-Pounder Mark IV Shrapnel Shell. Machinery, vol. 9, no. 222, December 28, 1916, pp. 321-325, 14 figs.

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See also Hydraulics.

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PUMPS AND PUMPING ENGINES

Motor-Drive of Hydraulic-Elevator Pumps, Charles J. Carlsen. Electric Review, vol. 69, no. 25, December 16, 1916, 4 pp., 4 figs.

High-Lift Centrifugal Pump. The Engineer, vol. 122, no. 3182, December 22, 1916, 1 p.

Davey's Compound Condensing Pumping Engine. The Mechanical Engineer, vol. 38, no. 988, December 29, 1916, pp. 495-496, 5 figs.

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The Baldwin Locomotive Works. Proceedings of The Engineers' Club of Philadelphia, vol. 33-7, no. 144, November 1916, 12½ pp., illustrated.

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STEAM ENGINEERING

Steam Station of Ohio State Power Company. Electrical World, vol. 68, no. 27, December 30, 1916, 4 pp., 6 figs.

Om Kontrollering af Mollierdiagram, Tore Lindmark. Teknisk Tidskrift, vol. 46, no. 111, December 1916, 4 pp., 3 figs.
Mollier diagram control.

Deighton's Steam Boiler. The Mechanical Engineer, vol. 38, no. 986, December 15, 1916, 1 p., 3 figs.

Sulla Vaporizzazione della Caldaia Ordinaria per Locomotiva. Prof. E. Grismayer. L'Ingegneria Ferroviaria, vol. 13, no. 22, November 30, 1916, 6 pp.
Vaporization in an ordinary locomotive boiler.

Fuel Economy and Boiler Design, J. T. Anthony. New England Railroad Club, October 10, 1916, 41½ pp., 12 figs.

Relationship of Boiler Heating Surface to Economizer, M. C. Sherman. Power, vol. 44, no. 26, December 26, 1916, 2 pp., 1 fig.

Theoretische Grundlagen für die Mittelbare Erzeugung Künstlichen Saugzuges, M. Pfotenhauer. Dampfkessel und Maschinenbetrieb, vol. 39, no. 45, November 10, 1916, 4 pp.
Theoretical bases for the production of mechanical draft (continuation).

Action of Boiler Water Tubes in Service, John C. McCabe. Journal of the Ohio Society of Mechanical, Electrical and Steam Engineers, vol. 9, no. 1, November 16, 1916, 4½ pp., 3 figs.

†The Willans Line for Steam Turbines. Engineering, vol. 102, no. 2657, December 1, 1916, 1 p.

†Operation of Curtis Steam Turbines and Alquist Reduction Gears in the Propulsion of Cargo Ships, W. J. Davis, Jr. General Electric Review, vol. 20, no. 1, January 1917, 6 pp., 5 figs.

Water Rates of Auxiliaries, R. von Fabrice. Power, vol. 44, no. 26, December 26, 1916, 3 pp.

Power Equipment for Steam Plants, Robert L. Streeter. Industrial Management, vol. 52, no. 4, January 1917, 17 pp., 15 figs.
Part V. Superheaters.

CHARTS

Chart that Facilitates Making Calculations for Checking Up Rawhide Pinions Substituted for Cast-Iron Pinions. Machinery, vol. 9, no. 220, December 14, 1916, 1 p.

Diagram for Finding Specific Speeds of Turbines. Canadian Engineer, vol. 31, no. 25, December 21, 1916, 1 p.

Feed Lines. Practical Engineer, vol. 21, no. 1, January 1, 1917, pp. 35-38, 8 figs.

Pipe Covering. Practical Engineer, vol. 21, no. 1, January 1, 1917, 3 pp., 4 figs.

Expansion in Piping. Practical Engineer, vol. 21, no. 1, January 1, 1917, 7 pp., 14 figs.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

LIBRARY NOTES

From the Library of the United Engineering Society, Engineering Societies Building, New York. Includes Accessions to the Libraries of the Four Founder Societies

Annual Report of Library Board

The Library Board administering the Libraries of the American Society of Civil Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Institute of Mining Engineers, maintained as the Joint Library of the United Engineering Society, has just issued its annual report for 1916.

On August 16, 1916, when the American Society of Civil Engineers became a Founder Society, it entered into the same library agreement as the other Founder Societies. Its collection of books, which was started more than forty years ago and contains nearly 90,000 accessions, has therefore been added automatically to the Library of the United Engineering Society. This collection has for many years been a working civil-engineering library and all of the books (with the exception of periodicals) have been thoroughly analyzed and indexed. This library is particularly rich in engineering works of historic interest. It will be most valuable to the engineering profession when merged into the Library of the United Engineering Society, since it will furnish 67,000 entirely new accessions. The books are still in the house of the American Society of Civil Engineers, but will be moved to the Engineering Societies Building within a short time.

Photostat Room in Library of United Engineering Society

The Board for 1916 consisted of

Edward D. Adams	W. M. McFarland
W. P. Cutter	Harold Pender
J. V. Davies	Calvin W. Rice
Karl Eilers	Lewis D. Rights
Alfred D. Flinn	E. F. Roeber
George A. Harwood	Samuel Sheldon
Alex. C. Humphreys	W. I. Slichter
Charles Warren Hunt	Jesse M. Smith
F. L. Hutchinson	E. Gibbon Spilsbury
John W. Lieb	Bradley Stoughton

Leonard Waldo

Messrs. Davies, Flinn, Harwood, Hunt and Rights were added to the Board on October 13, 1916, to represent the American Society of Civil Engineers, which became one of the Founder Societies of the United Engineering Society on August 16, 1916.

Accessions to the Library during the year amounted to 2902 pieces, and the collection totaled, on December 31, 1916, 63,199 volumes.

The Library has received many notable gifts of books during the year. In addition to this, Dr. James Douglas generously donated the sum of $100,000, the income of which will be used for library purposes as mentioned in the last issue of The Journal.

Quite a large section of the report is devoted to the subject of recataloguing, which the report states must be undertaken in the near future. The necessity for this arises from the fact that when the libraries of the original three Founder Societies were united, their catalogues were assembled so as to form a catalogue of the united collection. The Dewey system had been employed in making each set, but many entries in

the catalogue, requiring judgment, had been determined by at least three different minds from different points of view. The resultant catalogue therefore lacks consistency. The report further states that it would not be wise to undertake this recataloguing before a satisfactory classification has been made of sufficiently broad scope to comprehend the library collection of the future. The report contains a time study of the processes of cataloguing and the determination of the cost to the Library of cataloguing various kinds of books.

Installation of Photostat Machine

Photographic processes for reproducing maps, plates, diagrams, manuscripts and material from printed books, have been in use by engineers and other workers for many years. These processes have been slow and expensive. A few years ago, however, there was developed a machine which makes possible the quick reproduction of such material at a slight expense. Photographs are produced on bromide paper without the intervention of a glass plate.

As will be seen from the illustration, the machine consists of a device for holding the object to be photographed, an apparatus for illuminating the object, and an optical combination of a lens and reversing prism. In addition, a camera capable of adjustment for focusing contains a roll of sensitized paper. The camera box is also provided with a mechanism to rotate the roll of paper, and a cutting knife to be used in separating a sheet of the paper after unrolling and exposure, as well as a manually-operated mechanism for transferring the severed sheet into the developing and fixing pans. The whole apparatus forms one unit. The lighting units are 200-watt Mazda C lamps, supported as shown on special stands.

The book or other object is placed as shown, the camera focused, an exposure of several seconds is made, the sheet rolled off and cut, and withdrawn into the developer; it remains there for the requisite number of seconds, and then is withdrawn through rinsing water into the hyposulphite fixing bath. The whole operation from the time of exposure to the time of fixing is not more than a few minutes.

The Library Board of the United Engineering Society installed in April, 1916, such an apparatus, with proper washing and drying auxiliaries, and has made prints for the clients of the Library Service Bureau during the last nine months of 1916.

This apparatus makes it possible to furnish anyone at a distance with an exact copy of any article in a technical periodical, including text illustrations, maps and diagrams, and thus renders, in connection with reference lists, the resources of the Library available to anyone within reach of the world's mails.

A charge is made to cover cost of labor, materials and current, which is figured at twenty-five cents per exposure.

W. P. C.

Am. Soc. M. E. Accessions

American Ceramic Society. Transactions, vol. XVIII. *Columbus, 1916.* Gift of Society.

Colorado Industrial Plan, John D. Rockefeller, Jr. Including a copy of the plan of representation and agreement adopted at the coal iron mines of the Colorado Fuel and Iron Company. 1916. n. p. Gift of author.

Cost Accounting and Burden Application, Clinton H. Scovell. *New York, D. Appleton & Co., 1916.* Gift of publisher.
Treats the subject in the following order: Material Cost; Labor Cost; Burden Cost, Manufacturing Cost; Selling Price. The last few chapters are devoted to special kinds of manufacturing: Foundry; Textiles; Paper and Candy. W. P. C.

The Factory—The Master Tool, by Max Toltz and W. E. King. *St. Paul, 1916.* Gift of Max Toltz.

Institute of Accountants in the United States of America. Year Book, 1916. *New York, 1916.* Gift of Institute.

International Railway General Foremen's Association. Proceedings of 12th Annual Convention. 1916. Gift of Association.

Lock Gates, Chain Fenders and Lock Entrance Caissons of the Panama Canal, by Henry Goldmark. Paper presented at the International Engineering Congress at San Francisco, 1915. *New York,* n.d. Gift of author.

Mediation, Investigation and Arbitration in Industrial Disputes, By G. E. Barnett and D. A. McCabe. *New York, D. Appleton & Co., 1916.* Gift of publishers.
This study is based on a report submitted in June, 1915, by the authors to the Commission on Industrial Relations. It is based on a survey of the agencies for mediation in Massachusetts, New York and Ohio. W. P. C.

U. S. Bureau of Lighthouses. Annual Report of the Commissioner, 1916. *Washington, 1916.* Gift of Bureau of Lighthouses.

U. S. Interstate Commerce Commission. Annual Report of the Chief Inspector of Locomotive Boilers. *Washington, 1916.* Gift of Interstate Commerce Commission.

U. S. Navy Department. Annual Report of the Paymaster General of the Navy, 1916. *Washington, 1916.*
——— Annual Report of the Secretary, 1916. *Washington, 1916.* Gift of Am.Soc.M.E.
——— Statement of Hon. Josephus Daniels, accompanied by Lieut. Byron McCandless. December 11, 1916. Gift of U. S. Navy Department.

Water Supply System, 1916. City of New York Department of Water Supply, Gas and Electricity. Gift of Municipal Engineers of the City of New York.

When is the Drilling of Off-set Wells for Natural Gas Justifiable? Samuel S. Wyer. *Columbus, 1916.* Gift of author.

Wisconsin Gas Association. Journal of Proceedings 13th and 14th annual convention. *Milwaukee, 1914-1915.*

U. E. S. Accessions

American Railway Association. Car Shortage Statistics. *New York, 1916.* Gift of Association.

American Society for Testing Materials. Proceedings of the Annual Meeting. 19th, 1916. 2 pts. *Philadelphia, 1916.*

Armour Engineer. General Index. vols. 1 to VIII, 1909 to 1916. *Chicago, 1916.*

Atlanta, Birmingham and Atlantic Railroad Co. Valuation of the property of, before the Interstate Commerce Commission. Gift of Clemens Herschel.

Bibliography of Australian Mineralogy, New South Wales, Department of Mines. Mineral Resources no 22. *Sydney, 1916.*

Boiler Code of the American Society of Mechanical Engineers, S. F. Jeter. Address before the National Association of Cotton Manufacturers, April 26, 1916. Gift of Frederick R. Hutton.

Boiler Safety Orders. Issued by the Industrial Accident Commission of the State of California. Effective January 1, 1917. *California, 1916.* Gift of Frederick R. Hutton.

Colorado Springs, Colo. U. S. Geological Survey, Folio 203. *Washington, 1916.*

Cotton Production and Distribution Season of 1915-1916. U. S. Census Bureau. Bulletin 134. *Washington, 1916.*

Descripcion de Algunas Plantas Liasicas de Huayacocotla. Ver. Boletin no. 34. Instituto Geologico de Mexico. *Mexico, 1916.*

Elementary First Aid for the Miner. U. S. Bureau of Mines. Miners' Circular 23. *Washington, 1916.*

Exploitation of Minerals in Mysore. Department of Mines and Geology. Gen. Ser. Bulletin no. 8. *Bangalore, 1916.*

Federal Valuation of the Railroads in the United States. Circular communication to chairmen of valuation committees. *December 15, 1916.* Gift of Clemens Herschel.

Federal Valuation of the Railroads in the United States. Statement prepared by Thomas W. Hulme, of the developments in connection with Federal valuation as of December 30, 1916. Gift of Clemens Herschel.

Field Geology, F. H. Lahee. *New York, 1916.*

Galena-Elizabeth, Illinois-Iowa. U. S. Geological Survey. Folio 200. *Washington, 1916.*

Geology of Cincinnati and Vicinity. Ohio Geological Survey, Bulletin no. 19. *Columbus, 1916.*

Gold Mining in Korea, Edwin W. Mills. Royal Asiatic Society, Trans. vol. VII, pt. I. *v. p 1916.* Gift of Edwin W. Mills.

Handbook of Westinghouse Watthour Meters. Publication no. 5150. Gift of Westinghouse Electric & Manufacturing Co.

Institution of Automobile Engineers. Proceedings. vol. X. *Westminster, 1916.*

Ironmonger Diary, 1917. *London, 1917.*

Kansas City Southern Railway Company. Tentative Valuation by Interstate Commerce Commission, November 20, 1916.
——— Report of the cost of reproduction new and cost of reproduction less depreciation. Engineering.
——— Summary and explanatory text of the land report. Gift of Clemens Herschel.

Legislation to Govern Construction of Boilers. Editorial from Dallas News, June 22, 1916. Gift of Frederick R. Hutton.

Lives of Alchemystical Philosophers, A. E. Waite. *London, 1888.*

Manufacture of Carbide of Calcium. Charles Bingham. *London, 1916.*

Mineral Resources of Mysore. Department of Mines and Geology. General Ser. Bulletin no. 7. *Bangalore, 1916.*

Mineralogical Society. By-Laws and List of Members, November, 1916. *London, 1916.*

Modern Theory of Solution, H. C. Jones. *New York, n. d.*

Napier, David, Engineer, 1790-1869. An autobiographical sketch with notes. *Glasgow, 1912.*

New Pearl of Great Price. A. E. Waite. *London, 1894.*

New Orleans, Texas and Mexico Railroad Company. Tentative Valuation by Interstate Commerce Commission, November 21, 1916. Gift of Clemens Herschel.

New York State Museum. Report of the Director, 1915. *Albany, 1916.* Gift of University of the State of New York.

New Zealand. Department of Internal Affairs. Annual Report of the Dominion Laboratory. 49th, 1916. *Wellington, 1916.*

Numerical Classification of Photography. *Rochester, 1916.* Gift of Eastman Kodak Company.

Ohio Boiler Inspection Law, 1916. Gift of Frederick R. Hutton.

Ohio Boiler Inspectors' Convention. Report of the Proceedings of First. *1916.* Gift of Frederick R. Hutton.

Pennsylvania Department of Labor and Industry. Second Industrial Directory, 1916. *Harrisburg, 1916.*
——— Department of Agriculture. Tabulated analyses of commercial fertilizers. Bulletin no. 282. *Harrisburg, 1916.*
——— Flavoring Extracts. Bulletin no. 285. *Harrisburg, 1916.*
——— Water Supply Commission. Annual Report. 1915. *Harrisburg, 1916.*

Pittsfield (Mass.) Ordinance Amending Building Ordinance. Gift of City Clerk.

Plea for Uniform Boiler Specifications, T. E. Durban. Paper read before the American Boiler Manufacturers' Association, September 1913. Gift of Frederick R. Hutton.

Practical Enameler, with Especial Reference to Enameling Sheet Steel and Cast Iron Ware. Otto Grampp. *New York, 1909.*

Production of Spelter in Canada, 1916. *Ottawa, 1916.*

Proposed Uniform Boiler Code. Louisiana Planter. Gift of Frederick R. Hutton.

Some Properties of Vibrating Telephone Diaphragms, A. E. Kennelly and H. O. Taylor. Reprinted from Proceedings of American Philosophical Society. vol. lv, 1916. Gift of Massachusetts Institute of Technology. Electrical Engineering Department. Bulletin no. 11, April 1916.

Specimens of British Minerals, Philip Rashleigh. *London, 1797.*

Technical Vocabulary, English-German, F. J. Wershoven. Ed. 2. *Leipzig, 1885.*

Texas Midland Railroad Company. Valuation of the property of. Before the Interstate Commerce Commission. Gift of Clemens Herschel.

Through the Air, John Wise. *Philadelphia, 1873.*

Underground Latrines for Mines. U. S. Bureau of Mines. Technical Paper 132. *Washington, 1916.*

Uniform Boiler Laws, T. E. Durban. Address before the Texas Cotton Seed Crushers Association, May 29, 1916. Gift of Frederick R. Hutton.

Uniform Specifications for Boilers, T. E. Durban. Address before 2d Pennsylvania Industrial Welfare and Efficiency Conference, November 19, 1914. Gift of Frederick R. Hutton.

U. S. Board of Engineers. Appointed to examine and report on plans adopted or designed for machinery of U. S. Vessels. Minutes of the Proceedings of. *Philadelphia, 1863.*

U. S. Bureau of Mines. Annual Report of the Director. 1916. *Washington, 1916.*

U. S. Bureau of the Mint. Annual Report of the Director, 1916, also the Report on the Production of the Precious Metals, 1915. *Washington, 1916.*

U. S. Census Bureau. Census of manufactures, general totals for the United States by geographic divisions, states and industries, 1914. 1909, 1904, and 1899. *Washington, 1916.*

U. S. Isthmian Canal Commission. Annual report of the Governor of the Panama Canal, with maps and diagrams. 1916. *Washington, 1916.*

Vapor Pressures of Various Compounds at Low Temperatures. U. S. Bureau of Mines. Technical Paper 142. *Washington, 1916.*

Victoria Mines Department. Annual Report of the Secretary for Mines, 1915. *Melbourne, 1916.*

Western States Water Power Conference. Call, Resolutions and Official Proceedings. September 21 to 23, 1915. *Portland, 1915.*

What is Preparedness? H. L. Gantt. Reprint from Engineering Magazine, September 1916. Gift of Frederick W. Taylor Co-Operators.

Wisconsin Gas Association. Journal of Proceedings. 15th Annual Convention. *Milwaukee, 1916.*

GIFT OF ALBERT F. GANZ

Effect of Electrolysis on Engineering Structures. Paper read at meeting International Engineering Congress, 1915.

Electrolytic Corrosion of Iron by Direct Current in Street Soil. Paper presented at 29th annual convention, American Institute Electrical Engineers, June 25, 1912.

Electrolysis from Stray Electric Currents. Before American Water Works Association, June 6, 1912; and New England Association of Gas Engineers, February 19, 1913.

Report, Investigation for stray electric currents in the City of Winnipeg and in adjoining municipalities, by H. A. Robson. *1915.*

Report on Electrolysis Conditions in Springfield, Ohio. *1914.*

Report on Insulated Return Feeder System for Mitigating Electrolysis installed by the United Railways Company of St. Louis, Mo., in the Ann Ave. substation district. *May 1914.*

GIFT OF INTERNATIONAL ENGINEERING CONGRESS

International Engineering Congress. Transactions vols. 1-11 and Index. *San Francisco, 1915.*

PERSONALS

In these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by February 16 in order to appear in the March issue.

CHANGES OF POSITION

David B. Clark, until recently with the Providence Engineering Works, Providence, R. I., has become superintendent of the American Shoe and Foundry Company, Erie, Pa.

John W. Clark, until recently associated with Hodenpyl, Hardy & Company, Inc., Jackson, Mich., has accepted a position with the Central Illinois Light Company, Peoria, Ill.

Frank E. Bardrof has resigned his position with the Pennsylvania Railroad, and is now connected with the Corning Glass Works, Corning, N. Y., in the capacity of machine designer.

Grandon D. Gates has become affiliated with The Celluloid Company of Newark, N. J. He was formerly connected with the A. Y. McDonald Manufacturing Company, Dubuque, Ia.

P. P. Henshall has accepted a position with the Stokes & Smith Company, Philadelphia, Pa. He was formerly instructor of machine shop practice at Pennsylvania State College, State College, Pa.

Edward W. Norris, recently connected with the Southwark Foundry and Machine Company, Philadelphia, Pa., has accepted a position as sales engineer in the New York office of the Mead-Morrison Manufacturing Company.

F. V. McMullin, formerly affiliated with the Pennsylvania Forge Co., Bridesburg, Pa., has assumed the duties of secretary and treas-

urer of the Richter Machine Company, Philadelphia, Pa., which has succeeded the Domestic Machinery Works.

John O. Heinze, who about a year and a half ago formed the John O. Heinze Company in Springfield, O., to make electric starting systems, has severed his connection with the company and has joined the Simms Magneto Company, East Orange and Bloomfield, N. J. He has been appointed engineer and production manager.

Thos. R. H. Murphy, formerly member of John H. Wallace and Company, New York, and recently engineer of the Mattagami Pulp and Paper Company of Toronto, has become chief engineer for the Port Arthur Pulp and Paper Company, Ltd., Toronto. Mr. Murphy will be in charge of building the company's 150-ton sulphite mill and 100-ton paper mill at Port Arthur, Ontario.

James U. Norris has assumed the duties of first assistant superintendent of the Presbyterian Hospital, New York. He was formerly connected with the New York Polyclinic Hospital, in the capacity of superintendent.

Robert Shirley, formerly mechanical engineer for the Pratt and Cady Company of Hartford, Conn., and works manager and engineer for The Chapman Valve Manufacturing Company, Springfield, Mass., for the past seven years, has severed his connection with the latter company. Mr. Shirley expects to take an extended vacation before again assuming manufacturing responsibilities.

ANNOUNCEMENTS

H. G. Brinckerhoff has been placed in charge of the Boston office of The Engineer Company.

Miss Kate Gleason of the Gleason Iron Works, Rochester, N. Y., has been elected vice-president of the Trailer Manufacturers' Association, recently formed at Detroit.

Charles B. Rearick, who has been acting as manager of sales for the Covington Machine Company for the past two years, is now located in Covington, Va., as vice-president and manager of the company.

Hugh M. Wilson, first vice-president of the McGraw Publishing Company, Inc., has tendered his resignation and will devote himself to his personal interests. Mr. Wilson has been vice-president of the company for the last six years.

Frederick W. Gay of San Francisco, Cal., announces that he has opened offices as consulting engineer, and will make reports, investigations, appraisals, and design, construct and operate power plants for public utilities and industrial plants.

Fred Ophüls, Halbert P. Hill and J. Harold McCreery, have incorporated under the firm name of Ophüls, Hill & McCreery, consulting engineers. They will specialize on the design and construction of power plants, ice and refrigerating plants and mechanical and electrical engineering.

George C. Hicks, Jr., vice-president and engineer of the P. H. and F. M. Roots Company, of Connersville, Ind., for the past 15 years, announces his retirement from the company on January 1, 1917. Mr. Hicks will act as consulting engineer for the company for a short time. Before taking up work again, he expects to take a six months' vacation.

Charles R. Courtenay, formerly superintendent and chief draftsman with the Watertown Engine Company and late with the New York Engine Company, and Robert E. Cahill have formed a partnership and will conduct business under the name of the Watertown Engine and Machine Company. The company will make a specialty of repairs and replacements to Watertown engines and boilers and, in addition, will do engineering work along the line of testing and adjusting power plant apparatus.

A. W. K. Billings has returned from Barcelona, Spain, where he has been for the past five years as manager of construction, managing director and vice-president of the Ebro Irrigation and Power Company, Ltd., and allied interests, in responsible charge of extensive hydroelectric construction and other work. Previous to his work in Spain and elsewhere for the Pearson interests, Mr. Billings spent two years in Pittsburgh and ten years in Cuba, principally on electric railway and power plant construction, and two years in New York as engineering manager of J. G. White and Company, Inc. He has opened an office as consulting engineer in New York, and will devote considerable attention to work in Europe and in Latin America.

APPOINTMENTS

Henry L. Barton has been made president of the Northway Motor and Manufacturing Company. Mr. Barton has been an executive of the General Motors Company for several years.

John H. Suter, formerly with the Snow Steam Pump Works, Buffalo, N. Y., the St. Joseph and Doe Run Lead Companies in southeast Missouri, and for the last two years with the Western Gas Engine Corporation, Los Angeles, Cal., as shop superintendent, has been appointed chief engineer and general superintendent of the Western Gas Engine Corporation.

Max E. Cutler, chief engineer of works of the Whiting Manufacturing Company, Bridgeport, Conn., has been appointed supervising engineer for Hamilton, DeLoss, Inc., who will erect a new factory immediately, with the intention of manufacturing metal goods and stamping in various kinds of metals. Mr. Cutler will still retain his position with the Whiting Manufacturing Company.

AUTHORS

F. De R. Furman is the author of a treatise on Elementary Cams.

Reginald Trautschold is the author of an article on Internal Spur Gearing, which appears in the January issue of *Machinery*.

J. C. Bertsch has contributed a paper on The Steam Jet Refrigerating Machine to the January number of *The Electric Journal*.

Gano Dunn has contributed an article entitled Professional Unity Among Engineers to the January 6 issue of *Engineering Record*.

Robert E. Cranston is the author of Gold Dredging in 1916, which appears in the January 6 issue of the *Engineering and Mining Journal*.

Advantages and Future of Electric Ship Propulsion, by W. L. R. Emmet, appears in the January 6 number of the *Electrical World*.

The Treatment of Export Inquiries, by Sterling H. Bunnell, is published in the January 4 number of *The Iron Age*.

Frederick C. Moore is the author of A Cost System for a Small Malleable Foundry, which is published in *The Foundry* for January.

An article on the Design of Oil-Ring Bearings by William Knight is published in the January 9 number of *Power*.

J. E. Johnson, Jr. is the author of Technical Advances in Iron and Steel, in the January 4 number of *The Iron Age*.

W. F. Durand has contributed an article to the January 6 number of the *Electrical World* on Progress and Outlook in Prime Movers.

B. S. Nelson of New Orleans, La., is the author of an article on Flow of Air Through Orifices Against Back Pressure, which is published in the January 4 issue of *Engineering News*.

Arthur J. Slade has contributed a paper entitled, What Motor Trucks Offer to Contractors, to the January 6 issue of *Engineering Record*.

Charles E. Knoeppel has contributed an article entitled How Profit-Sharing has Worked in Foundries, to the January issue of *The Foundry*.

B. A. Behrend is the author of The Signs of the Times in Generating Apparatus, which appears in the January 6 number of the *Electrical World*.

Charles A. Stone is the author of an article entitled Engineer's Relation to Foreign Expansion, which is published in the January 6 issue of the *Engineering Record*.

Harry L. Horning presented a paper on Seeking the Ultimate Tractor Engine, at the New York convention of the Society of Automobile Engineers, January 9 to 11.

Lawrence Addicks is the author of Metallurgy of Copper in 1916, which appears in the January 6 issue of the *Engineering and Mining Journal*.

Frederick Hymans presented a paper on Dynamic Balance of Rotating Parts and Dynamic Balancing Machines, at the convention of the Society of Automobile Engineers, held in New York, January 9 to 11.

Peter Junkersfeld, president of the Association of Edison Illuminating Companies, has contributed an article entitled, The Sale of Electric Service in Larger Quantities, to the January 6 number of the *Electrical World*.

G. R. Tuska presented a paper on Recent Developments in Design of Municipal Waste Disposal Plants, at the convention of the American Association for the Advancement of Science, held in New York, December 26 to 30.